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A JOURNEY IN SOUTHERN ABYSSINIA.*

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It will be remembered that in the year 1902–3 Mr. A. Butter, C.M.G., organized an expedition to explore the southern frontier region of Abyssinia. Captain P. Maud, C.M.G., R.E., was attached to the expedition to carry out survey operations, and to make recommendations for the future frontier line. The paper which he read before the Society is published in the *Geographical Journal*, 1904.

A treaty based on Captain Maud's recommendations was concluded in 1907, defining in general terms the boundary between Abyssinia and our colonies of British East Africa and Uganda. It also provided for the settlement of the boundary in detail by a delimitation commission; and in May, 1908, I was appointed to carry out the work of delimitation.

The frontier to be examined and marked out extended from the junction of the rivers Ganale and Daua in the east, to the southern terminal of the Sudan-Abyssinian boundary, at the intersection of 6° N. lat. and 35° E. long., in the west, a length of about 600 miles.

I proposed to organize the expedition at Dire Daua, the terminus of the Jibuti railway, and to march thence to the eastern end of the frontier *viâ* the Hawash valley, Ginir (on the Arussi plateau), and the Web valley, calling at Addis Abbaba to make arrangements with the Abyssinian representatives on my way. From its eastern terminal I proposed to follow the frontier westwards, and was anxious to arrive in the mountainous districts north-west of Lake Rudolf before the rains broke. Major Austin's hardships on his 1901–2 expedition were due to his being headed out of this region, into the low-lying and barren districts of Lake Rudolf, by the rains. I hoped at the completion of our

* Map, p. 232.

work to be able to return through south-western Abyssinia by previously unexplored routes, instead of following Major Austin's track south to Nairobi, or north to the Sobat river.

The most favourable time to start to carry out this programme would have been in March or April from Dire Daua. It would then have been possible to cross the Arussi plateau, lying between the Hawash and Web valleys, before the rainy season; and the frontier would have been reached towards the end of the rains, which are earlier there than on the plateau to the north. It was, however, impossible to collect animals and *personnel* at Dire Daua till the end of July, and this made it necessary to cross the Arussi plateau in the height of the rains. To have postponed the start till the end of the rains would have rendered it impossible to reach the western end of the frontier before the following rains. Moreover, the lack of water in the height of the dry season greatly interferes with freedom of movement in the frontier districts; and this difficulty was considerably felt, even starting when we did.

On the British Commission were: Captain R. Waller, R.E., assistant-commissioner; Captain G. Condon, transport officer; Dr. R. E. Drake Brockman, medical officer; Corporal C. Carter, R.E., and Sapper C. Favier, R.E., assistant surveyors. For native *personnel* I decided to rely exclusively on Somalis, Abyssinians being useless with camels, the only reliable or obtainable transport animals in the dry frontier region. Considerable difficulty was anticipated in getting camels across the high ground on the way to the frontier, but all loads were arranged so that they could be subdivided for mule transport, which I counted on being able to hire in the northern districts.

Leaving England by the P. & O. steamer sailing June 12, we reached Dire Daua July 4, calling at Aden to make final arrangements for the enlistment of our Somalis. While waiting for the arrival of Somalis and camels from Berbera, survey operations were started at Dire Daua, loads prepared, riding mules and ponies purchased, etc.

The camels and Somalis arrived July 28, bringing the strength of the expedition to a total of six Europeans and about ninety natives, all Somalis except one or two Abyssinian and Galla interpreters. Our transport consisted of about one hundred camels, with a dozen riding mules and ponies. A few hired Abyssinian mules were also engaged to take me to Addis Abbaba, while the permanent caravan proceeded direct. Our Somalis were untrained men, but I had arranged to arm about 70 per cent. of them. We were fortunate in being able to secure Mr. Butter's old headman, Mahomed Hassan, of whose services I cannot speak too highly. The success of the expedition was largely due to his immense power of work, loyalty, and intelligence.

As everything was in readiness, the expedition started from Dire Daua on July 30. We were content to move slowly, as our animals were in poor condition, and the weather bad. This, however, fitted in

with the execution of survey work; moreover, owing to the regrettable illness of the Emperor Menelik, I had heard from Sir John Harrington that there would probably be some delay in appointing Abyssinian representatives. We followed what is known as the Assobat route, skirting the foot of the Harrar plateau, along the probable trace of the extension of the railway to Addis Abbaba. This is now the most generally used route to Addis Abbaba, the old Harrar route on the uplands being almost abandoned. At some seasons, when water is plentiful and the Hawash not too high to ford near Bilen, the "desert" route, which passes north of the Afdubba and Assobat mountains, is used. It is, however, too hot and dry for comfortable travelling, though it is used by the bullock-cart service which now runs in the dry season, and by the emperor's traction engines in their annual trip from the capital to Dire Daua and back. We reached the Hawash on August 20, and from this point I proceeded direct to Addis Abbaba, leaving the main caravan to wait in the neighbourhood of the telephone for definite orders.

Captain Waller was able to utilize the time in survey work, and he made the ascent of Mount Fantalli. At the summit he found a large and deep crater, from which a certain amount of steam was rising; a jet of steam also broke through the wall of the crater on the northern slope of the mountain. Although the district is obviously highly volcanic and there are several small broken-down craters in the surrounding plain, I do not think Fantale has previously been recognized as a volcano.

I arrived at Addis Abbaba August 27, the last 60 miles being most unpleasant travelling. The black clay soil and saturated atmosphere of the high plateau combine to produce deep, clinging mud of the worst description. Travellers who consult their comfort should not make the journey in the months from June to September (inclusive). From Addis Abbaba I was able to telephone to the main caravan to continue their journey to Ginir, where they were to await my arrival, as I was detained at the capital owing to the illness of the emperor.

In the dry season the easiest route for the main caravan would have been over the comparatively low neck connecting the Arussi to the Harrar plateau at the northern end of the Gugu mountains, and thence by the low ground to the east of those mountains and of the scarp of the Arussi plateau. During the rains the tributaries of the Wabi * which intersect this area become impassable, and it was necessary to cross them at their sources on the Arussi plateau, at a height of over 8000 feet. Even on this route the southern Laga Arba, which drains into the Hawash, was in heavy flood, and much difficulty was experienced

* This correctly represents the local pronunciation of the name, the *a* being quite broad.

in crossing it. South of this stream the caravan had some days of easy travelling on the Abomso plain, a magnificent pasturage supporting great herds of cattle; and a fairly easy road was found up the scarp through the Fara Kassa district, the scarp rising in a series of fertile, well-cultivated terraces.

On the plateau the rains, which had showed signs of stopping, recommenced, and both the Somalis and camels felt the cold and wet very much, although the former were provided with Abyssinian tents and two blankets per man. The camels were kept alive by Captain Condon's energy and care in providing fires at night.

The officers paid a visit to the Alila Concession, where a little colony of enterprising Frenchmen—part missionary, part commercial—have established themselves on one of the spurs of the eastern scarp. The main object of the enterprise is to raise cattle for the markets of Aden, Jibuti, and the Red sea ports. The country is eminently suitable, and the railway extension will provide an easy means of transport. The main difficulty is the lack of organization to control cattle diseases. Rinderpest is prevalent in Abyssinia, and at any time the coast markets may be closed to Abyssinian cattle. M. Gros, the leading concessionaire, has another farm for the cultivation of coffee near the railway line, in the neighbourhood of Assobat. It is hoped that by the time the railway reaches the Hawash both enterprises will be in a position to avail themselves of the start they have of other competitors.

The main caravan made the descent from the plateau, and crossed the Wabi in the neighbourhood of Abu Kassim mountain. Here the camels were rested some days in the warmer climate before proceeding to Ginir, which was reached in the end of October.

Leaving Addis Abbaba October 24, I proceeded as quickly as possible to Ginir, making a plane-table sketch of the route based on a list of fixed points which Captain Waller had sent me. The Addo lakes, some 30 miles south-east of Addis Abbaba, consist in part of wide marshy basins and partly of a string of small, deep crater lakes. The surrounding district is fertile, but not densely inhabited. From Addo to the Mojjo river, a considerable perennial stream, the country is undulating and not so bare of trees as on the Addis Abbaba-Balchi road.

On the accompanying map an attempt has been made to show the formation of the scarp south of the Kasam river. In the north the scarp rises in two steps, the wedge-shaped plateau of Choba and Minebella forming the intervening terrace. To the south the steps converge and amalgamate, but the combined feature loses height by the drop to the south of the upper plateau and the rise in the floor of the Hawash valley. These combined effects lead to the breaking up of the scarp formation south of Tade Mariam. The descent at Tade Mariam is by a comparatively easy well-graded road.

I crossed the Hawash at the upper end of the marshy plain of

Wanji. The river flows here between low clay banks, and the plain is almost entirely flooded in the rains. In the dry season it affords excellent grazing, and temporary villages are built on it. The plain is bounded by dry, stony, bush-covered spurs, from which the scarp of the Arussi plateau rises steeply in a series of highly cultivated terraces. At the foot of the latter, Laga Kalata is a charming perennial stream.

Halfway up the scarp is Sirre, a small Abyssinian village and customs post. It has a curious little church consisting of a stone-built cube, surmounted by a sharp steeple-like roof, also of stone. The church was probably a Mohammedan shrine originally, similar to that at Sheikh Hussein and others in the Arussi country. The last 1500 feet of scarp is very steep, but not difficult for mules. From the top I had a wonderful view back over the Hawash valley, north to the Danakil plain, and west past Mount Zukwala into the heart of the main plateau. The opposing scarp, from Ankober southwards, runs in a great wall, crested with the more distant mountains round Addis Abbaba. It was a glorious day of blue sky and driving white cloud-masses, throwing shadows of all gradations of blue and purple, while the ripe cornfields and pasture-fields on the terraces below were gold and green in the sun.

The route now struck across the main Arussi plain, or "Dida," parallel to, but some miles to the west of, that followed by the main caravan. The plain is a great sheet of pasture land, devoid of trees, slightly undulating, but a good deal flatter than the plateau on the opposite side of the Hawash, which it slightly exceeds in height. It is bounded on the west and south-west by the Chillalo and Bale mountains, and rises in the north-east to the Gugu mountains, which form a connecting link to the Harrar plateau. To the north it drops in the scarp already described to the Hawash valley, and in the east to the Wabi basin. The plateau is a great basaltic block, and its eastern edge is eroded in a remarkable fashion by the Wabi tributaries, which have cut deep cliff-sided gorges, leaving long narrow tongues of the original block projecting. The Wabi has cut right across the plain up to the foot of the Chillalo mountains, and divides the plateau into two distinct parts.

I was on what is known as the Bale road, and followed it almost to the edge of the Wabi ravine. Here the Ginir road branched eastwards along the tongue separating the Wabi and Robi gorges. The ground maintained its elevation, and was level right up to the edges of the cliffs, which dropped sheer on either hand. As the gorges converged breaches occurred in the tongue, converting it into a serrated ridge, and affording a possible line of descent for the track over the *débris*. Looking either way across the Wabi gorge, here some 7 miles wide from cliff to cliff, the eye is struck by the extraordinarily level line of the plateau. The effect was emphasized by an isolated table-topped block

of precisely the same height left standing in the middle of the gorge. The river flows at a level of about 3000 feet, some 4000 feet below that of the plateau.

The Wabi was crossed November 1, a fine stream some 30 yards wide, 3 feet deep, and flowing 4 miles an hour. The flood-level is very much higher, but is probably that of sudden spates which flow off rapidly. The ascent on the side of the ravine was shorter than the descent, but by a better track. Either would have been impracticable to camels, and Captain Condon was fortunate to find a possible road further east. The Mohammedan shrine of Asser Osman was passed halfway up the ascent in a cultivated side valley.

On top the southern "Dida" is bare, uninhabited, and badly watered. Travelling was made unpleasant by the pungent smell of great tracts of a species of marigold, which grew 4 or 5 feet high in the neighbourhood of all previously cultivated ground. Both the "Didas" were formerly thickly inhabited, as is evidenced by the marks of cultivation. Where the Galla States yielded without fighting, as in Jimma and Wallega, Menelek left them a large measure of autonomy, and loyally kept his promises of fair treatment. In case of opposition his policy was one of extermination, as these Arussi districts witness. The survivors are almost exclusively pastoral, except in the immediate neighbourhood of the Abyssinian posts, where they are concentrated to carry on sufficient cultivation to maintain the garrisons.

At Sabro a terrace-like formation marked the first drop to the lowlands of the south, the next drop being just beyond Ginir, up to which place the undulating grass-covered uplands extend.

On arrival at Ginir I found the main caravan in a deplorable condition. More than a third of the Somalis were down with fever of a bad type, and our transport animals had suffered greatly, in spite of Captain Condon's care. The officers, too, had had a good deal of fever, and were far from fit. I had hoped, from Dr. Donaldson Smith's description, to find plenty of supplies and transport animals at Ginir, but the place had lost much of its importance as a trade centre. It should be a considerable market for salt, obtained in the district between the Wabi and Web, and also for ivory; but it had been used of recent years as a jumping-off place for raids against the Ogaden, and traders were afraid to venture there. The main traffic is the lucrative, though illicit, trade in arms.

During the year previous a large raiding party from this district had come in collision with the Italian garrison of Lugh. Two Italian officers were killed, and the Italian Government insisted on the punishment of the governor, Dejaj Lul Segad, who was in consequence removed from his post. His following, on withdrawal, looted the neighbourhood, and the garrison established by the new governor extorted what little was left for their immediate wants.

NATIVE TYPES IN THE MARKET AT MAJI. ABYSSINIANS, GALLAS AND BLACKS, A KAFFA WOMAN IN CENTRE.

CAVE DWELLINGS ON AKAKI STREAM, NEAR ADDIS ABBABA.

VIEW ACROSS WADI RAVINE, SHOWING THE LEVEL LINE OF THE SOUTHERN WALL.

ADDIS ABBABA. GIBBA OR PALACE IN MIDDLE DISTANCE, AND BRITISH LEGATION IN FOREGROUND.

We were fortunate in meeting Lieut. Perducchi, an officer attached to the Italian Legation at Addis Abbaba, who had just returned from a reconnaissance of the proposed Italian frontier east of the Juba. He kindly provided us with much useful information about the route to the south, and prospects of obtaining fresh transport animals and supplies on the way.

At Ginir we found ourselves again involved in a rainy season, the outskirts of the November rains of the Somali coast falling heavily in the district. Although bad for the health of the men, these rains probably facilitated our march to the south by improving the water-supply. Leaving Ginir November 6, we at once dropped down another terrace-like formation into the thick bush of the Web valley. To the east the flat-topped Galbi and Jabis mountains are evidently the remains of an old plateau almost entirely eroded by the action of the Wabi and Web. The track down the valley proved easy over hard sandy ground. The dense thorn bush with which the whole country was covered would have proved a serious obstacle, but fortunately the Abyssinians had cleared a wide track by which to drive back the great herds of cattle collected on their raids.

There are a few nomadic Gallas in the upper Web valley, for the most part not pure blooded, but crossed with Somalis. The pure Somali population begins at the 6th parallel, though it is very sparse, owing to the dispersion caused by Abyssinian raids.

The track kept away from the river till Heile Modo was reached, after which point the bush became thinner and the tributary water-courses less deep cut. The Web was still in half flood, and carried a quantity of red sediment, in marked contrast to the clear water of the Wabi.

We reached the junction of the Daua and Ganale rivers on November 29, and found a post of the Boma Trading Company established at Dolo on the right bank, with Mr. Horneyold and his assistant Mr. Vincent in charge. Though the rivers were still in half flood, a loan of two Berthon boats, belonging to the company, relieved us of much difficulty in effecting a crossing. The animals swam the rivers about 2 miles above the junction without casualty.

We now began the traverse of the frontier from east to west, following the south bank of the Daua river. The upper course of the river, as described by Captain Maud, flows in a deep gorge worn in the elevated steppes of the Boran country, but from the neighbourhood of Muddo the valley opens out and its sides are less sharply defined. The river is generally easy of access, and there is a good track tangential to its windings.

From Malka Sala, 20 miles east of Muddo, I left the main caravan and, with Mr. Zaphiro, the frontier inspector employed under the Addis Abbaba legation, visited the Somali districts south of the Daua.

The districts traversed constitute a vast bush-covered plain broken only by a few low hills. The range which determines the eastern bend of the Daua near Malka Sala, though presenting a steep and mountainous aspect from the river, is insignificant when viewed from the south. The plain is practically waterless in the dry season, and the inhabitants move to the rivers or to the few permanent wells, such as those of El Wak, when the semi-artificial reservoirs or "haras" dry up. They delay their move as long as possible, as the district affords abundant good grazing, and is healthier for man and beast than the river neighbourhood, owing to immunity from mosquitos and "fly."

As our journey was a hurried one, undertaken with the object of meeting some tribal headmen, we travelled chiefly by night, and complete or accurate survey was impossible. We crossed Baron von Erlanger's route twice, but only the southern point could be definitely identified.

The perennial wells of El Wak are scattered at varying intervals, in great numbers, for probably some 20 miles or more, along the course of what must be a subterranean water-channel. No surface watercourse is apparent, nor any clearly defined depression. A characteristic of the district is a soft white stone, producing a fine penetrating dust, which indicates a change in geological formation banking up the water.

El Wak, the well of God, is capable of supporting an immense number of cattle. In the past it has been more utilized than at present, and many old wells are choked. The great difficulty at these oases in waterless countries is, not so much the watering, as the feeding of the cattle collected round them. It is rare for this reason to find the "karias" or temporary villages in immediate proximity to the wells, and it is extraordinary the distance cattle are driven from the grazing grounds to water. I have come across villages over 12 miles from water, and it is difficult to see how cattle get any time for feeding or repose when each drink entails a journey of 20 to 30 miles. It is no wonder they look wretched creatures in the dry season, but they put on condition wonderfully quickly when the young, moisture-laden grass begins to shoot. The isolated perennial waters have the great advantage of being comparatively immune from raids in the dry season, as it is impossible to drive cattle away from them.

We had a trying march on the long waterless stretch from El Wak to Takabba. The latter is the most easterly of the group of kopjes composed of huge sienite boulders scattered south and east of the Goro escarpment. There are, as a rule, several small wells at the foot of the kopjes, but these seldom provide water throughout the dry season. They are not, I believe, spring fed, but tap reservoirs among the boulders of the hill. From Takabba we rejoined our main body, which had advanced to Banissa, a point on Captain Maud's survey.

Dr. Drake Brockman had unfortunately developed black water fever

just after I left Malka Sala, and it was with great difficulty Captain Condon had carried him, when convalescent, over the 56 miles of waterless track from Muddo to Banissa. The high ground at Banissa proved much more bracing than the Daua valley, and the health of all the Europeans, which had up to then been unsatisfactory, rapidly improved. It was, however, necessary to invalid Dr. Brockman home, and notes of the route he followed on his journey to Addis Abbaba are given in Appendix I.

From Banissa Captain Waller proceeded to Gof, in the Boran country, to pick up Captain Maud's triangulation and extend it eastwards. The remainder of the Commission went back to the Daua at Malka Murri, where the frontier leaves the river. Following the frontier westwards from this point, we met Captain Waller again at Hara Reisa, among the Jara kopjes.

Thence we made south to Gaddaduma, at the eastern end of the Goro scarp. This feature has been very fully described by Captain Maud, but it is of such importance that a few more words may be said about it. The scarp marks the southern limit of the Boran upland, which, though it rises to the crest of the scarp in the south, slopes away gradually to east and west. The scarp is, so to speak, a retaining wall, and the fall of the country east and west to the north of it leaves the wall projecting in a line of hills, where the soil at its back has disappeared.

It will be observed that the scarp forms a blunt salient in its centre. The western limb runs parallel to the strata, and is little indented, while it is only at the very end of the wall that a passage opens through it. As might be expected in this section, little water is found at the foot of the scarp. The limb east of G. Gomo is very different in character. Breaking as it does across the strata, the scarp is intersected by numerous deep valleys containing a perennial water-supply, and forming the resort in the dry season of the people who in the wet season live in this portion of the Golbo plain. At its eastern extremity, where, as I have described, the backing of the wall has disappeared, the valleys lead through, leaving a string of more or less isolated hills.

Gaddaduma is the first of the valleys to break through the scarp wall, and is also the most easterly which contains perennial water. It has, therefore, a special importance in its double capacity as a source of water and as a pass from the upland districts to the western Golbo. The water-holes at the foot of the Goro scarp are not only resorted to by natives, but also by elephants in great numbers.

It is reported that the elephants which frequent the Lorian swamps, towards the end of the rains, graze their way northwards to the foot of the scarp, where there is much good feeding. They arrive there at the beginning of the dry season, and there they must remain till the rains return, as the water-holes which served them on their way north dry

up. The dry areas to east and west of the scarp equally prohibit lateral escape. Whether the elephants come from so far south I cannot say; but they do, undoubtedly, congregate in the dry season in enormous numbers along the eastern portion of the scarp, and, as they come to water, fall an easy prey to Abyssinian hunters. Menelek has prohibited this wholesale destruction, but it is too profitable a trade to be easily stopped.

From Gaddaduma Captain Maud kept to the highlands, but it was necessary for us to work along the foot of the scarp to complete his survey. Travelling was unpleasantly hot at this lower level, and the stench of dead cattle, the victims of a severe visitation of rinderpest, did not improve matters. The rinderpest had been particularly bad on the Boran highlands, and the country was full of Abyssinians attracted by the opportunity of gorging themselves with meat. The natives were only too glad to dispose of their moribund animals. Much of the meat was dried and carried away, but the whole idea is rather horrible, and justifies the comment of "hyænas" made by our Somalis, always glad of an opportunity to turn up their noses at Abyssinians.

At Churre Moyale we came to Mr. Zaphiro's headquarters, where, with true Greek adaptability, he was making the best of his isolated position. An excellent garden had been made, and several acres of ground placed under cultivation. Building, too, had been started on a carefully thought-out plan.

Moyale, or rather Fort Harrington, as Mr. Zaphiro has named his station, is situated at a height of 6000 feet, on a spur projecting from the main plateau, up which leads the important, though at present little used, trade route from Kismayu, *viâ* the Wajjeira oasis, to Boran and central Abyssinia. This route may well become some day a considerable trade artery either by the use of mechanical transport, in the way of which there would be few obstacles, or by the improvement of water-supply, the present chief difficulty. Fort Harrington is therefore well placed as a healthy administrative post and as a possible commercial centre.

From Moyale, bidding good-bye to Mr. Zaphiro who could accompany us no further, we again descended to the plain. It was now the middle of February, and water was hard to come by. Little sustenance was left in the dried-up vegetation, and marches were perforce long and hot. It was wonderful, under the circumstances, how our riding animals survived at all, sometimes going from forty to fifty hours without water. We followed the foot of the scarp to its western extremity, after which we followed Mr. Butter's route, *viâ* Gorai and Sardu to Lake Stefanie, without breaking new ground, and making few additions to Captain Maud's map.

The most remarkable feature in these regions are the lines of craters running south-west from the scarp, first at Mogado, and, further west,

the Dillo and Gorai group. The latter are especially curious, notably Dillo, hardly showing a projecting rim above the general level of the ground, but forming cliff-lined pits some half-mile in diameter and several hundred feet deep. The lakes which form in them dry up, but brackish water is obtainable from wells at the bottom of the craters which support large herds of camels and sheep during the dry season.

The last march from Sardu to Lake Stefanie was a particularly trying one. When Mr. Butter traversed the country the rains had commenced, and water was obtained in several places where we dug for it fruitlessly. At Lake Stefanie we found hot springs, giving a good supply of water, though salt and, after the first, nauseous to the palate. The lake was drier even than Captain Maud had found it. The creek along the south-east shore had disappeared. Owing to misty weather and mirage, we could not definitely fix the limits of the water remaining, but bearings fixing approximately the limits to south and west were obtained.

The western wall of the rift in which Stefanie lies is steep and inaccessible for transport animals. I consequently sent the main body round by the route followed by Captain Maud, and went in a direct line across the lake myself. The floor of the lake is hard, sandy, and flat. The difference of a few feet in level would enormously affect the water area. There is no reason, I think, to suspect any raising of the lake bottom, nor need one suppose that it is permanently drying up. The natives round Lake Rudolf report that there has been a succession of abnormally dry seasons; and a shallow sheet of water like Lake Stefanie would quickly show the result where evaporation is so great. It would take several abnormally wet seasons to make good the wastage, and even then I doubt if the water-limit shown by the earlier explorers would be maintained throughout the year.

At Lake Stefanie we reached the western limits of the Gallas and Somalis in these latitudes, though to the north the former extend much further west. It would be impossible, in the scope of this paper, to give a detailed description of the subdivisions of these races which we had encountered, and I will confine myself to a general account of their distribution.

As already recorded, the Arussi Gallas (Mohammedans) do not extend in the Web valley beyond the 6th parallel, where a pure Somali population begins. Till recently these Somalis were Dagodi and other detached groups of the Hawiyah. Many of them have, however, sought refuge in the country between the Ganale and Daua, or even among the tribes south of the latter river, and there is a tendency for their places to be filled by sections of the Aulihan Ogaden, who dread the mullah's raids more than those of the Abyssinians. The whole population in these regions is, in fact, in movement in a general south-westerly direction under the combined influences of the mullah's and Abyssinian

aggression. Much inter-tribal quarrelling ensues, and there is a dangerous tendency to acquire firearms.

South of the Daua river and west of the Juba river is the powerful Marehan tribe in two main sections, the Rer Isak and Rer Hassan. A formidable detachment of the Aulihan Ogaden Rer Afgab has lately settled here also, and there are various minor tribes established along the Juba river. The latter are responsible for what little cultivation is done. West of the Marehan comes the very numerous tribe of the Garre. They occupy to El Wak and along the Daua as far east as Malka Re. Although of pure Somali origin, and nominally Mohammedan, they have to a large extent adopted the language and many of the superstitions of the pagan Boran Gallas.

To the west of the Garre, who do not extend beyond the east end of the Goro escarpment, are several minor tribes of Somali origin, who have even to a greater extent than the Garre lost their original religion and language. The chief of these are the Rendile and Gabra. The former I have not met, but I believe they show, like the Gabra, unmistakable signs of their origin in dress and speech.

The Gabra are also found scattered both among the Boran and Garre, to whom equally they occupy a semi-servile position. The Boran and Somali tribes raise both cattle and camels, but the former are essentially cattle and the latter camel owners. Both are only in a limited sense nomadic, the range of their movements being as restricted as the exigencies of water-supply permits. The Boran, who have as a rule a plentiful water-supply and good grazing, move in specially circumscribed orbits. Many of their village sites may be looked on as permanent, though the huts are elementary, non-permanent structures.

Between Lakes Stefanie and Rudolf we saw no sign of the Arbore, who had probably retired north, as the country was almost waterless and destitute of grass.

From Lake Stefanie to Lake Rudolf we took the shortest line possible following the principal watercourse south of Loya hill, and found water at two places in it.

Reaching Lake Rudolf, February 22, we followed the shore northwards, passing an Abyssinian post on a slightly elevated spit just opposite the mouth of the Omo. In the neighbourhood of the post was a considerable settlement of Gelaba, a low-grade black tribe allied to the Lokob, who cultivate and raise cattle for the Abyssinians.

Captain Maud's Indian surveyor, sketching the Omo mouth from a distance, must have been deceived by flood-water or mirage. The lake does not cover nearly as much ground as he shows, and Bòttego's map more accurately represents its limits. Much of what Captain Maud's map shows as lake was, at the time of our visit, under cultivation. There were several small lagoons near the river, which probably increase greatly in area when the river rises; but the general characteristics

of the vegetation were those of marshland, not dry lake bottom. It is, in any case, impossible to define the limits of the lake by a hard-and-fast line.

At Murle it became necessary to subdivide our caravan. It was out of the question to think of exploring the hilly country between the lake and Sudan frontier with camel transport, and we had a very limited number of donkeys and mules capable of carrying loads. With great regret I parted with Captain Condon, commissioning him to take the bulk of our party with the two non-commissioned officers by the best road he could find, direct to Addis Abbaba.

Finding that the route to Gardula would be dry, and difficult for camels, he decided to make his way through Bako and Uba. This was the route followed about a month later by Captain Stigand. With the exception of the pass out of the Omo valley to Bako, where native porters were supplied by the Abyssinians, the route proved a good one, and easy for camels, although many were lost through eating poisonous shrubs. When the B.E.A. railway system is extended, and steamers are placed on Lake Rudolf, it should prove an important trade artery.

Crossing the Omo at Kerre, a considerable village, Captain Waller and I made first for Mount Nakua. There were several small Abyssinian posts and some native population on the right bank of the Omo where Major Austin had found the country deserted in 1901. Mount Nakua, which we ascended, proved to be a highly volcanic formation with a well-defined crater at the north-east end of the mountain. The day of our visit was misty, and we could not see distinctly to what extent Saunderson gulf had dried up. There was certainly no water at its northern end, and so far as could be seen from this point and from the Gelaba ridge, only an isolated lagoon, as indicated on the map, remained. The Kibish river splits up immediately west of Nakua, and no permanent channel reaches the lake. The neighbourhood of the Kibish was uncultivated and uninhabited, though an abandoned Abyssinian post remained.

Leaving the Omo, we had been unable to procure guides, but Major Austin's admirable map fulfilled all our requirements, although we had considerable difficulty in finding water. When we reached the junction of the Kibish, with the watercourse draining the southern slopes of Mount Naita, it became a question what our next move should be. Our objective was the plateau from which Naita rises, but the scarps running to the north and to the west were very formidable, and there were no tracks or sign of human habitation, except some abandoned shelters of Abyssinian hunters, to guide us. The Kibish ran some 12 miles from the foot of the scarp, and to attempt a direct ascent, unless we could find water nearer, might lead us into great difficulties. Reconnaissance parties sent out to search for water could find none, and

reported the ascent very difficult and hampered by thick bush. The alternatives were, therefore, to follow Major Austin's route west in search of an easier place of ascent, or to march by Bòttego's route up the Kibish. Against the former was the fact that the country was much drier than when traversed by Major Austin, which meant we should probably find little water on his route. To follow Bòttego's route was to involve ourselves in higher ground, and would also necessitate a considerable *détour*. Influenced by the water question, I decided on the latter course, hoping to find a track up the scarp short of the point where Bòttego made his ascent, or at least to obtain guides at the villages marked on his map.

We found easy going as far as the junction of the Kiba and Kibish, but after that were compelled by thick bush to follow the channel of the former, where heavy sand proved very trying. We experienced great difficulty in finding water in the lower Kibish, and it was not till the upper reaches of the Kiba were reached that it became plentiful. The villages marked by Bòttego either near the river or on the slopes of the scarp had completely disappeared.

On March 10 we reached a dry watercourse which seemed to come from the col connecting the Kanta mountains with the southern plateau, and turned up it, leaving Bòttego's route. As no water could be found in the neighbourhood of our camp, we could not wait to make a thorough reconnaissance of the ascent, but started up by what appeared to be the easiest line. The mules and donkeys, on which we had chiefly relied, were frequently in difficulties, but the few camels we had brought with us proved excellent climbers. They were some of a batch purchased at Gorai, and were the stoutest-hearted camels I have ever met. To see them throw themselves on their knees and wriggle up slopes where mules had to be hauled, revolutionized one's ideas of camel nature.

The line we had taken proved well chosen, and, to our great relief, we found ourselves on top in four hours, having made the ascent of 2000 feet without any sort of track to guide us. Our luck did not stop there, as we marched straight to a water-hole, a few miles from the top, which proved subsequently the only one within a radius of over 10 miles. A small party of armed natives watched us as we reached the top, and several villages were in sight. The natives fled, however, and, when we visited the villages, found they had been deserted for some months.

We were uncertain whether the villages had been deserted as the results of Abyssinian raids, or owing to shortness of water. Our first business was, therefore, to get in touch with the natives we had seen, and to ascertain what prospects there were of finding water on our route to the south. I sent out the indefatigable Mahomed Hassau and three other small parties with this object, while the animals rested. Mahomed, covering nearly 60 miles in twenty-four hours, located a deserted Abyssinian post and found water some 25 miles to the south. He failed

BAKO PLATEAU.
(*From a Photo by N. C. Cockburn.*)

HARRAR FROM THE WEST.

LOOKING UP THE GANALE AT DOLO, WITH THE DAWA RIVER ENTERING ON THE LEFT OF THE PICTURE.

(*From a Photograph by Dr. R. E. Drake Brockman.*)

THE WEB RIVER.

to meet any natives, and reported that all the district south showed the same signs of recent desertion. Two other Somalis, however, discovered a scouting party of six natives asleep, and, running in, secured two. The other four made off, but, being reassured by the two captured, all six were finally induced to come to camp. They were a quaint party. Black and rather short, with close-cropped hair, and the lobes of both ears pierced and distended to an enormous size. They carried shields of Turkana pattern, and were armed with spears and knives, the former provided with sheaths. We had to set to work to acquire a vocabulary, as they knew neither Galla, Amharic, nor Somali. By degrees we learnt that they belonged to the Surma tribe, and that about a year previously the Abyssinians had established a small post in the country. They had at first lived on good terms with the Abyssinians, but about four months before our arrival a raiding party appeared, who seized their women and cattle. Some of the tribe fled westwards, but many were killed, and the bulk of their cattle had been taken. The chief of the tribe with a small remnant was still established at Turmu, a spur on the escarpment overlooking the Kibish, a few miles north of Mount Naita. Marching south, we found this settlement, and established friendly relations with them, though they were timid and constantly on the look-out for parties of Abyssinian marauders.

The Turmu spur is a remarkable natural stronghold. Flanked on each side by deep wooded ravines, it consists of a series of rounded summits equalling the plateau in height, and linked together by knife-edge cols some 500 feet to 1000 feet lower. The villages, permanent structures, were situated on the summits, forming strong defensive positions, and, more important, offering easy means of escape into the thick bush of the ravines below. The women of the tribe made themselves indescribably hideous by distending their lower lip with a wooden (or leather) disc, causing it to protrude from 2 to 3 inches at an angle of about 45° below the horizontal. The people are cattle-owners chiefly, but carry on a little cultivation as well.

Near Turmu we found a man who had been with the Abyssinians for some years, and could speak Amharic. From him we learnt that previous to the Abyssinian invasion there had been a considerable dispersion of the tribe, owing to shortage of water during the last three or four years. He said that his tribe were allied to the Boma people, but not to the Turkana. They were divided into two sections. The Surma Wali Zogish, inhabiting the Baras district in the north, between Kutul Birino (the "Central peak" of Macmillan) and the Kibish valley; and the Surma Kumeru Doleti, inhabiting the Durgane district of the plateau near Turmu. The villages shown by Böttego on the watershed between the Kibish and Akobo had apparently belonged to the former subtribe, but had been wiped out by earlier Abyssinian raids.

From Tumu we marched south-west to Mount Tamitiro on the

southern scarp, passing Mount Naita, which was obviously inaccessible. We made the ascent of Tamitiro, getting an extensive view of the southern scarp and the country to the south. The scarp proved to be considerably lower than that bounding the Kibish valley, and was clear of bush, which is by no means as dense or extensive as shown on Major Austin's map. It would probably have been easier to reach the plateau from this side, although the crest of the scarp is marked by a continuous "Krantz" or cliff line, which might have rendered ascent difficult.

From Tamitiro we turned north to Central peak. The country to the west was reported dry and uninhabited; and, covered with grass and sparse bush, its appearance confirmed the report. This portion of the plateau appears to share with the desert country below it the general name of Kuruno. The Abyssinians, however, I think, apply the name Tirma to the whole block of plateau south of the Akobo and west of the Kibish basins. It is always exceedingly difficult to obtain names accurately in districts recently occupied by Abyssinians. Their raids disturb the local population, and the officers forbid any information to be given to Europeans. Moreover, the Abyssinians are slow in picking up native names, and the few they use are either names applied by themselves or gross distortions of native names.

The Tirma plateau drains to its centre, and thence north-west by a deep gorge, which, I believe, issues into the western plains as the Karuno river of Major Austin. There is a considerable amount of game, especially in the western half of the plateau. Buffalo, zebra, and eland were seen. The last named have not previously, I believe, been reported so far north to the east of the Nile.

From the reports of the Macmillan expedition I had anticipated some difficulty in traversing the country south of Central peak, but it proved easy. The ground is stony, but there is much excellent grazing. Where the drainage gathers in the centre of the plateau are springs and a good supply of water. Elsewhere there was great scarcity. We ascended Central peak, and fixed a number of points to the west, several of which appear on Major Austin's map. The triangulated values confirm his work, based on chronometric methods, in a remarkable way.

I should like, also, to pay a tribute to the excellence of the maps produced by the Bòttego expedition. Based as they are on chronometric methods, errors in places are inevitable. The general representation of the relief of the country is good, though, owing to the system of shading adopted, landmarks are sometimes difficult to identify, and minor features exaggerated. The information as regards the population enfaced is excellent.

We had now completed all essential work on the boundary; and as the rains, which were overdue and had been threatening for some weeks, broke the evening we came down from Central peak, I decided

to go no further north. It would have been interesting to explore the wedge of country between Austin's and Bòttego's routes, but the work had been already partially done by the Macmillan expedition, and the state of our transport did not warrant taking unnecessary risks. Since our arrival on the plateau we had lost most of our camels from poisonous shrub, and our mules and donkeys, having been fly-bitten in the Kibish valley, were daily losing strength, and several had already died.

The natives reported a large Abyssinian post on the highlands to the north-east, and to make for it was the surest way of obtaining supplies and fresh transport animals. My original idea, therefore, of returning through Abyssinia proved the most feasible, and I was glad of the opportunity of seeing Kaffa, and the southern portion of the Omo-Nile watershed.

On March 20 we turned our faces home, much to the delight of the Somalis, who were getting pretty tired of marching and a meat diet.* They were at first sceptical that they would be required to climb no more mountains, which was to them a very poor substitute for the big-game shooting they had previously associated with exploring expeditions.

We descended into the Kibish valley not far from our first camp on the plateau, by a well-worn track used by the Abyssinians. We had missed this track on our march up the Kiba, owing to its having been obliterated by elephants where we crossed it.

The districts of Taigu and Duku, between the Kiba and Kibish, which Bòttego shows as thickly inhabited, are now entirely deserted. Beyond the Kibish, which, unlike the Kiba, is a beautiful perennial stream in its upper reaches, we found the first traces of habitation. The eastern slopes of the valley, which we ascended to the base of the Tiski mountain by a curious knife-edge spur, are cultivated by a colony of blacks collected by the Abyssinians. They call themselves Yedu, but I doubt if they are a distinct tribe.

The Abyssinians make a practice in these newly acquired districts of collecting colonies of what they term "prisoners of war" to cultivate the neighbourhood of their cantonments, the garrison subsisting largely on the produce. A species of plantain is one of the chief objects of cultivation. Its pith is ground to flour, though the fruit is inedible, being largely composed of hard seeds. Sweet potatoes, yams, and several cereals were also grown.

From the Yedu we were able to recruit porters to carry our loads up the last 2500 feet to the plateau on which the Abyssinian post of

* I provided only two months' rice ration, for use at the start, and for issue to small parties. For the remainder of the time the Somalis subsisted and throve on a purely meat diet, chiefly camel flesh, frequently that of worn-out transport animals. They eat no salt with their meat even if issued to them.

Maji was situated, at a height of over 8000 feet. Very few of our animals were able to struggle up even without loads.

There was a considerable garrison at Maji, and the officer in charge, Kenyazmach Rata, one of Ras Woldo Giorgis' men, received us courteously and assisted us in hiring enough mules for our further journey. Mr. George Clerk, of the British legation, had some years ago, I found, made Maji his headquarters when on a mission to the Rudolf districts. The ways of Englishmen were, therefore, well understood, and things arranged themselves more quickly than is generally the case in Abyssinia.

The Maji plateau is a buttress projecting from the Nile watershed between the Omo and Kibish valleys. It is a portion of the true high-level Abyssinian plateau. Although many of the south-western portions of Abyssinia have been so fissured and eroded that the country, at first sight, presents a tangle of mountain ranges, it never really loses its character of a deeply scored plateau. The apparent mountain-tops form the true original level, which varies little. For this reason lines of communication keep to the high ground as much as possible; valleys are seldom followed for long, but are, as a rule, crossed perpendicularly.

We left Maji March 27, and thence to Jimma, owing to the interlocking of watersheds, had one of the most "switchback" journeys imaginable. The Maji colony extends only a few miles north of the post, and beyond it we again found a country bearing all the signs of former cultivation, but quite deserted. This was attributed to a drunken Abyssinian officer formerly in charge, who burnt and killed for the love of it.

The Geisha district some way to the west of the road contained another Abyssinian post, and appeared populous. Beyond it again to the north-west was the plateau block of Daka Sameida, whose southern bastion is called Bokol on Major Austin's maps. This marks the beginning of Ras Tasamma Nado's territory, and he has a garrison there. South of the Birbirwaha, a considerable stream, apparently the headwaters of the Gelo, the country was known as Surma, and the original inhabitants were allied to those of Tirma. North of it is Golda. The Abyssinian station in this district is particularly prosperous, well built, and cultivated. It is always easy to judge the character of the officer in charge by the appearance of the posts, which vary from industrious colonies to robber strongholds. In this case the officer in charge was a Wallo Galla, and as a rule the Gallas are mild, peaceable, and industrious. Crossing the Birbirwaha we had dropped to a level of 3800 feet, but passing through Golda the track rose steadily, following a long narrow spur which bounded on the south the deep-cut gorge of the Golda stream. The level of the main plateau was attained at the Omo watershed. The drainage is almost entirely to the west, and the water-

shed corresponds practically with the crest of the steep escarpment dropping to the Omo and Dincha.

From Bashama on the watershed, which here trends away to the north-west, the track descended to the Shire, which is the first considerable feeder of the Dincha. The Golda district extends to the Shire, and on the northern slopes of the valley is a small district called Suro, also inhabited by a black population. These slopes form the southern scarp of the Kaffa plateau, and the crest sharply defines the dividing line between the black and brown peoples.

In Kaffa, much of the ground is clothed with dense forests of magnificent trees covered with ferns and parasitic creepers. To the south we had seen a few patches of this genuine forest, but for the most part the country would be more accurately described as bush-covered than wooded, though the mimosa trees grow large and there are a considerable number of the giant Abyssinian fig trees. In Kaffa there is also a quantity of very high bamboo, whose influence was at once apparent in the architecture of the villages and carefully made fences.

The clearings in the forest showed an exceptionally fertile soil, and were either cultivated or clothed in rich fine grass. In places narrow strips of forest had been left in hedgerow fashion, and the whole appearance of the country was singularly un-African. Perhaps it was the presence of bamboo structure that suggested pictures of Japanese landscape, and a higher plane of civilization.

Passing so rapidly through the country, and without proper interpreters, it was impossible to ascertain much about the people. They are a race evidently quite distinct from the Gallas to the north, with a different language and religion. In colour they resemble the Gallas, but are finer in feature and lighter in build. Beke states that their language is similar to that of a tribe in Damot, north of the Abai, which confirms my surmise that they are a remnant of the race which inhabited this part of the plateau before the Galla invasion.

The Gallas have penetrated like a wedge, driving part to the north and leaving this section isolated in the south. This may explain, too, why so much fine plateau country had been left to low-grade blacks south of Kaffa, and why the Gallas did not penetrate further in this direction. The Kaffa people, strong enough to hold their own in the mountain and forest fastnesses, had yet no tendency to expansion, and merely shielded the black tribes, turning the direction of the Galla wave. It would be interesting to know whether the Walamo, who, I understand, are also a brown race distinct from the Gallas and on a high plane of civilization, are allied to the people of Kaffa.

The ethnology of Southern Abyssinia is very interesting, and there is much scope for scientific investigation, impossible on the hurried journeys made by modern travellers, who are moreover confused by

the overlying veneer of Abyssinian influence. The Galla race is especially interesting, as, in the opinion of most Europeans acquainted with the country, the future of Ethiopia lies with them. Yet little is known of them, and it is difficult to pick up even the broad facts of their distribution from the map. There seems little doubt that, like the Somalis, they are of Asiatic origin, and invaded Abyssinia from the Gulf of Aden. Occupying the Harrar plateau, they spread south into the Arussi and Boran countries, north into Wallo, and drove a wedge westward through Shoa, south of the Abai, right to the scarp overlooking the Nile plains.

They exhibit a curious mixture of paganism and Mohammedanism. It would seem as if the advanced waves of invasion had been pagan, and that only the later comers were Mohammedans. Thus the Lega Gallas in the extreme west, and the Boran in the south, show identical forms of paganism, though separated by many miles of country inhabited either by black tribes or the Mohammedan Gallas of Jimma. It is remarkable and yet consistent with this theory that the pastoral and agricultural habits of the Gallas do not follow the religious division. The pagan Boran are a pastoral people like the Mohammedan Arussi, while the Legas Gallas are agricultural, and intimately resemble in personal attributes and in their architectural and agricultural methods the Mohammedans of Jimma. Their religion, therefore, is not associated with their habits of life. Considering the wide dispersion of the race, the Galla language shows surprisingly few variations. The racial type with its round head, high large forehead, short straight features, burly frame, and phlegmatic nature is also very uniform. Only in the east, where there are at times strong traces of Somali blood, does it vary much.

Proceeding through Kaffa, we found the old capital, Bonga, practically abandoned. The chief centre in the Guicho valley is now Anderacha, where there is an important market in a fertile district. A high forest-covered tract separates the Guicho from the Gojeb, widening in the east to form the Kullo district. Close to the crest of the escarpment on the south side of the Gojeb is Sherada, the chief station or Katama of Ras Woldo Georgis. This place is conected to Addis Abbaba by telephone, and the line is continued into Kullo. As, however, about 60 per cent. of the insulators are broken, communication in the wet season is interrupted.

The Gojeb is a good-sized stream some 60 feet wide, draining in its upper reaches a fairly open valley, but entering a narrow gorge to the east of our road. It forms the boundary between Kaffa and Jimma. On its northern bank the ground rises easily in open, thinly populated spurs to the Betetu pass, which is forest covered. Once across the pass there is a fine view into the rich, cultivated, and populous valley of the Gibbe.

Jimma displays a good instance of the Emperor Menelek's policy. Before invading the state he offered terms to the Abajifer, or sultan. These secured complete local control and immunity from Abyssinian interference in return for an annual tribute and assistance in the war with Kaffa. The Abajifer accepted the terms the more readily as Kaffa was his hereditary enemy. As a consequence, Kaffa, once the richest state in Abyssinia, is now largely depopulated, while Jimma prospers exceedingly under its own rulers.

The Abajifer or Sultan of Jimma is an intelligent, rather obese man of middle age, who takes great pride in the prosperity of his country. Road-making is his hobby, and many of the roads could be used for wheeled traffic without further improvement. He is more open in manner than most Gallas, who, as a rule, are a singularly suspicious and cautious race. His Mohammedanism is far from strict; but one would not expect Gallas to be fanatical, as they are an easy-going people, heavy and stolid compared with Abyssinians or Somalis.

The Abajifer's residence, or jiren, is an elaborately stockaded enclosure—a perfect rabbit warren of courtyards, passages, and houses thronged with retainers. The houses of the ordinary people are not grouped in villages, but in separate homesteads. The dwelling-houses are surrounded with lines of miniature buildings in which grain is stored, presenting as a whole a grotesque resemblance to a hen with a family of chicks. A similar arrangement is adopted by the Lega Gallas in the west.

From Jimma to Addis Abbaba the road was easy, with the exception of a steep pass over the Dikki mountains. North of these hills the Gibbe cuts a deep cliff-sided gorge before it reaches the Omo. The Omo, which also goes by the name of the Gibbe in its upper reaches, was, where we crossed it, some 60 yards wide, and rapid, but not deep. A bridge is provided for use in flood. The approaches to the river are easy at the crossing, but a short distance below it enters a deep gorge, and there can be few lines of access.

From Maji to Jimma we had had a great deal of rain, but from Jimma to Addis Abbaba the weather cleared a little. All reports agreed that in the south-west the rains are earlier and more severe than at the capital.

At Addis Abbaba, which we reached on April 20, we found Captain Condon's party, which had arrived a couple of days before. After about a week's enjoyment of Lord Herbert Hervey's hospitality at the Legation, we proceeded to Dire Daua, relinquishing survey operations for the first time.

We arrived at Dire Daua May 10, nine and a half months from the date of our departure, in which the main caravan had covered well over 2000 miles, and some detachments almost 3000. The Somalis had, on the whole, done exceedingly well, and for that we were

especially indebted to the admirable work of Mohammed Hassan, who seconded Captain Condon most loyally.

It would have been impossible to find more hard-working and loyal companions than Captains Waller and Condon. Captain Condon had relieved me of the greater part of the responsibility for discipline and transport arrangements, and on Captain Waller fell all the more irksome work of survey. Such results as we obtained are, in the main, due to their exertions.

APPENDIX I.

NOTES FROM DR. R. E. DRAKE BROCKMAN'S REPORT ON HIS JOURNEY FROM BANISSA TO ADDIS ABBABA.

Dr. Drake Brockman left Banissa on December 29, and travelled north-west through El Mole and Chillako. At the latter place are four wells, 20 to 25 feet deep, hewn in solid rock and giving a permanent supply of water. Beyond Chillako the names of districts shown on Captain Maud's map require slight amendment, the correct order being Kokob Billow, Dumbulla Billow, Andar, and Boku. The last-named place, just short of Gullgullo, marked the south-eastern limit of the rinderpest visitation.

At Gullgullo the water, much fouled by cattle, is contained in two pans having an ironstone foundation and covering an area of about 2 acres. The next place where a plentiful water-supply was found was at the wells of Chokorso; there were many Boran in this neighbourhood.

The heads of families among the Boran bedeck themselves with necklaces of beads, brass or white-metal wire, or, with what they prize most, necklaces made from the stiff hairs of the giraffe's tail. It is not uncommon to see an individual wearing a dozen of these on his neck. Bracelets of white metal or brass, covering the whole of the forearm, are also much in vogue, with a coil of the same metal wound round almost the entire length of the little finger, with the exception of the terminal phalanx.

Skirting the northern side of an undulating plain studded with isolated conical hills, permanent water was found at Wallen, in two wells 20 feet deep and 10 inches in diameter. Seventeen miles further on, there was a large pool of water at the base of G. Gurbi, a conical mass of rock. At Wujili there are two groups of wells situated in a large open space in the bush. The main group consists of eleven serviceable wells and others old and fallen in. Each well starts with a long tortuous passage, leading to a trough neatly built and plastered with mud. Three feet lower is another trough, and beside it is the well, usually some 20 feet deep. In the well is a crudely fashioned ladder, and on this five or six men arrange themselves, and with the invariable chant, "Ho, ho! He, he, he! Ho, ra, ho! He, he!" pass the water out in leather buckets to the lower trough, from which another man bails it into the cattle-trough. Wujjili is probably the largest watering-place of the Boran.

From this point, after about two hours' travelling through dreary bush, the track enters a park-like country abounding in game. Along to the right are the mountains of Jum Jum and a small range on which Arrero, the most southerly Abyssinian post, is situated. There are no posts in Borana itself, the Sultan being left in charge.

From G. Es and G. Livu low hills converge towards the west, forming the valley in which are situated the wells of Webb, somewhat similar to, though deeper than, those of Wujili. A short distance beyond Webb, Dr. Brockman's route crossed the main track from Arrero to Higo, and ran thence through fine park-like country to Hara Digalla, where there was water in two deep dams. From Hara Digalla to Digaleh the country is hilly, and evidently rises considerably, acacias giving place to cedars and wild olive at the latter place.

The main route from Sidamo to Higo passes Digaleh, but after following it for a short distance, a route over cedar-covered hills was taken to Darrito, where at the foot of G. Obdai, the village of Geddu, Sultan of Borana, is situated. According to an Arab trader, who had just made the journey, from Kismayu to Darrito takes twenty-two days—*i.e.* Kismayu to Wujjeira, ten days; Wujjeira to Churre Moyale, seven days; Moyale to Darrito, five days. The road, he stated, was safe; but in the dry season it is necessary to carry water from Affmadu to Wujjeira, seven days.

Dr. Brockman left Darrito on January 13, after having had an interview with Geddu, and took the route passing through El Boro and Sorupa, which with Hogal are the permanent watering-places of the fine grazing district of Gomoleh. Shortly beyond Sorupa the track joined the main route from Borana to Jum Jum and Sidamo. From Finchawa, a permanent pool in a well-wooded valley, it passes through magnificent forests to Kuya, the boundary between Borana and Jum Jum. Continuing through beautiful country, the Gololcha river was crossed, running west in a clear stream some 10 feet wide.

Steadily rising till the summit Yabasir was reached, an extensive view was obtained, and it was noted that the track had led along a range of mountains running north and south, parallel to which were other ranges divided by grassy valleys. Away to the west were the high mountains of Burji, apparently continuous with the Korso range, and beyond was the great rift-valley with its chain of lakes, L. Abbaba being plainly visible across the Burji range. The neighbourhood of Yabasir, which is in Uraga subdistrict, is the southernmost limit of the Jan Jumtu, or Jum Jum Gallos.

Although many Boran carrying grain on camels and donkeys from the markets at Gatallo had been passed on the road, yet the whole of the beautiful districts of Dagamo and Magada, between Gomoleh and Uraga, are for some unaccountable reason uninhabited. They are fairly well matured, and afford good grazing. The forest trees, which often bear flowers, rise to a height of 60 or 70 feet, laden with ferns, orchids, and other parasitic plants, among which is a species of mistletoe with red berries.

Gatallo, a long valley through which flows westward a river of the same name, is the most important market of the Jan Jumtu. Beyond Gatallo from Halo, which, like the Abyssinian posts, is perched on a hill, a superb view was obtained. To the south-east lies the district of Darasa, separated by the Galana river from Guji to the west and south-west, into which the track descends. The gallas of Guji are distinct from the Jan Jumtu.

From Halo there is a well-marked track to Alata, the headquarters of Dejaj Nado, governor of Western Sidamo. Dejaj Tafari, son of Ras Makunen, is governor of Eastern Sidamo, with his seat at Abera, on a mountain range 15 miles east of the track. Passing Alata, the descent was made through a hilly and fertile country to the Gidabo river, which is 40 to 50 feet wide, and crossed by a substantial native bridge. From the crossing, the post of Shisha was visible, on a mountain range 15 miles to the south-east, and to the north of it lay the district of Walisha.

From the Gidabo the forests were left behind, and undulating grass country, with patches of bush and cultivation, took their place.

Kasiyi, the district beyond Dambara, is to a large extent uninhabited, and beyond that is a flat plain belonging to the Arussi. Alaba, a district near the Bilatte river, has some cultivation and excellent grazing. Ababa is the southernmost district of Guragwe, and is under Dejaj Abatu, governor of Kambata, the district on the other side of the Bilate. From Yimbirbir on the Bilate river to Urbarag is a magnificent plain, dotted here and there with acacias and giant fig trees.

At Urbarag, Dr. Brockman joined the route traversed subsequently by Captain Condon and Captain Stigand, which the latter has described.

APPENDIX II.

Notes on the Construction of the Map.

The map published with this paper is based on two systems of rapid triangulation linked together by a line of latitude and azimuth observations; and, consequently, all longitude values can be referred to a common origin. One triangulation system extends approximately along the 9th parallel N. long., from Harrar in the east to the Sudan frontier in the west. The other is an extension of Captain Maud's triangulation in the Boran and Lake Rudolf districts.

In describing the progress of the work, which is the result of three expeditions, chronological order will be followed.

1. When at Addis Abbaba in 1901, I measured a base with steel wire, and extended a triangulation to prominent points in the neighbourhood, using a 3-inch theodolite. Travelling westwards, I extended the triangulation along the line of route as far as the Wallega plateau between the Dabus and Didessa. Tulu Wallel and J. Bela, two points intersected from Wallega, had been approximately fixed, in the previous year, from stations on a line of latitudes and azimuths carried along the Sudan frontier. This line depended, in turn, on a triangulation system whose origin was the telegraphically fixed position of Khartum. The 1901 triangulation gave, therefore, a direct though weak connection with the Sudan values. I did not attach much value to the connection, as the work was done by rapid methods with a small instrument; and west of the Didessa the line value lost accuracy owing to lack of well-placed and defined points. Moreover, the intersection of Tulu Wallel and J. Bela, from a difference in latitude base, did not give a refined value for those points. I decided, therefore, at the time not to reject the longitude value I had adopted for Addis Abbaba, which approximated to a mean of two values by occultation observations obtained in 1897 by Major Swayne, R.E., attached to the Rodd mission, although Major Swayne's exact observation point could not be identified.*

2. In 1902–03 Captain Maud accepted the same value for Addis Abbaba as the origin of the line of latitudes and azimuths he ran from G. Zekwala (a point on my Addis Abbaba triangulation), to the Boran country; and, consequently, as the origin of his triangulation.

3. Starting work in 1908, I decided to attempt to link together Harrar, Dire Daua, and Addis Abbaba by triangulation; and to connect the system to the eastern terminal of the frontier, at the Daua Ganale junction, at least by a line of latitudes and azimuths. It was important to have the eastern terminal in the same terms as Captain Maud's work; as, from his description, there would be little

* A discrepancy at the closing points of about 2′ long. was noted.

possibility of extending his triangulation all along the frontier, and some means of checking and adjusting the detailed survey lying east of his work was desirable.

The programme promised results of considerable cartographical interest in affording a rigid framework for the map of Southern Abyssinia, to which the work of previous explorers could be adjusted. To obtain an approximate value for the origin of the triangulation to be commenced at Dire Daua, and to check the previously assumed value for Addis Abbaba, Captain Waller observed for time at Jibuti, and the following night at Dire Daua, carrying three watches. This gave a chronometric value for Dire Daua based on the chart value of the observation point at Jibuti. The same procedure, reversed, was adopted on our return journey, and the values obtained on each occasion were practically identical.

Latitude observations were of course also made at Dire Daua; but, unfortunately, neither at the beginning nor end of our journey could a really satisfactory set be obtained; partly owing to cloudy weather, partly to our theodolites * not being in perfect working order. The accepted mean is, however, I have no doubt, a close approximation to accuracy. A base was measured with steel wire, checked by a steel tape, at Dire Daua and extended to the neighbouring hills.

From stations on the Harrar scarp, St. George's church, on the watershed of the Errer river, some 2 miles west of Harrar, was intersected. It was satisfactory to find that the value obtained agreed closely with that previously adopted from chronometric values on the latest War Office maps, as there have been considerable discrepancies in the position assigned by cartographers to this important place.

From Dire Daua Captain Waller extended the triangulation westwards, making no attempt to beacon forward points, or to observe all three angles of the main triangles. Time available put such methods out of the question. We had to be content with a rapid triangulation, and a line value obtained from well-defined intersected points, giving well-conditioned triangles of considerable size. The conditions were fairly favourable, and the line values were always the mean derived from several points. Azimuth values were checked at frequent intervals.

Some difficulty was experienced in carrying the triangulation through the passage between the scarp and the Afdubba and Assobat mountains, the intersected points being too near and too high above observation stations. A fresh base was consequently measured and extended near Laga Hardim, a weak check on the previous line value being obtained. The connection between the two triangulations depends, however, on the intersected values of several common points.

From the new triangulation points were fixed on the main Addis Abbaba and Arussi scarps. Wet weather and cloud made it impossible to continue the triangulation beyond Balchi, on the former; but two of the points fixed, G. Boka, near Balchi, and a high peak in the Ankober neighbourhood, were also visible from the Addis Abbaba mountains. I was able, therefore, when the weather cleared, to intersect them by a slight extension of my old triangulation at Addis Abbaba.

Comparison of the values obtained from the Dire Daua and Addis Abbaba origins respectively gave the following results:—

	Latitude.		Longitude.
Value of Ankober point—			
From Dire Daua	9° 17′ 22″·7	...	39° 31′ 52″·5
From Addis Abbaba	9° 16′ 56″·7	...	39° 30′ 14″·5
Difference	26″·0	...	1′ 38″

* We were using 5-inch micrometer theodolites.

	Latitude.		Longitude.
Value of Boka point—			
From Dire Daua	8° 53′ 26″·4	...	39° 16′ 06″·7
From Addis Abbaba	8° 53′ 0″·3	...	39° 14′ 24″·7
Difference	26″·1	...	1′ 42″

As the Boka point is a rounded one, difficult to intersect accurately, the discrepancy between the two origins may be taken as 26″ of lat. and 1′ 38″ of long. I think the connection between the two triangulations may be taken as adequate for cartographical purposes, though it was unfortunate the weather conditions made it impossible to fix more common points.

The discrepancy in latitude is curious, and must, I think, be in the main attributed to local deflection of the plumb-bob. It is true that the latitude observations at Dire Daua were not satisfactory, but their probable error is nothing like 26″. At Addis Abbaba three distinct series of observations were taken by Captain Maud and myself, and they agree to within 2″. The position of Addis Abbaba on top and Dire Daua at the foot of a high plateau mass give conditions favourable to strong local disturbance.

As regards the discrepancy in longitude, it is impossible to speak definitely. At least three main sources of error exist, viz.—

1. The chart value of Jibuti.

2. The chronometric position of Dire Daua as regards Jibuti, including both chronometric and observational errors.

3. Major Swayne's value for Addis Abbaba, including observational errors from a variety of causes and uncertainty as to exact observation point.

For the final origin value I have adopted in latitude a weighted mean between the Dire Daua and Addis Abbaba observations, deducting 16″ from all values depending on the former, and adding 10″ to the latter. After some hesitation, I have decided to accept the longitude value obtained for Dire Daua as being, on the whole, most convenient. It fits with the previous position of Harrar on the War Office maps, and also with the Sudan frontier work in the west; while in the case of Captain Maud's work only an alteration of meridian line is necessary.

To revert now to Captain Waller's triangulation in the Hawash valley. Although it was possible to fix points on the Arussi scarp, the formation of the ground and prevalence of clouds prevented a direct continuance of the triangulation. A fresh base was, therefore, measured at Tulu Shato, and connected with the previous work by latitude and azimuth. This small triangulation carried us to Ginir, but south of that point thick bush and lack of well-defined features made triangulation impossible. A continuous line of latitudes and azimuths was, however, with considerable difficulty carried to the Daua-Ganale junction, short bases being frequently measured to connect inaccessible points with the observation stations.

The value obtained at the Daua agreed fairly closely with that obtained chronometrically by Bòttego. The error found in his work by Captain Maud accumulated later in his journey. An attempt was made to triangulate along the course of the Daua, but this had soon to be abandoned owing to the thick bush masking all features. For the survey of this portion of the frontier traverses were made with measuring-wheel and compass, checked at intervals by latitude and chronometric observations. The adjustments finally necessary between the terminal points were small, and the chronometric values, though showing no marked discrepancy, were rejected in favour of a uniform adjustment of the traverses.

The eastern portion of Captain Maud's map was not covered by triangulation, but was plane-table work, depending on his most easterly latitude and azimuth points. Captain Waller reoccupied some of Captain Maud's stations, and extended his

triangulation east to the Jara hills, and south to G. Roka, Churre Moyale, and G. Burroli, intersecting many hills beyond the Goro escarpment. Some slight adjustment and amplification of the outlying portion of Captain Maud's map were found necessary.

West of Burole no extension of the triangulation and only minor additions to the detail were necessary till Lake Rudolf was reached. There Captain Waller reoccupied the Loya and Rocky hill stations, and extended the triangulation west to the Tirma plateau, and thence northwards to Kaffa. The work had to be dropped finally owing to wet cloudy weather, and from Anderacha to Karossa, a point on our route in lat. 8° 8′, only a plane-table sketch, checked by occasional latitude observations, could be made. The strong local disturbances of the compass rendered it difficult to work accurately without fixed points, and at Karossa a discrepancy of about 2′ in longitude was found when the position was checked by a latitude and azimuth fixing from Jibati, a point on my 1901 triangulation.

The topographical details of the map are in the main from plane sketches, on scales of 1 : 250,000 or 1 : 500,000, made by Captain Maud's surveyor or by members of the delimitation commission. With these have been compiled a sketch of the Gildessa, Harrar, Addis Abbaba upland road made by Count Gleichen in 1897, also the route in the Hawash valley of the Harrison expedition in 1898. The course of the Ganale is from Böttego's map, adjusted between points fixed by Captain Maud and Captain Waller with some slight modification from Baron von Erlanger's map. The route of the latter in the Marehan district is also shown. My own route in the same district is from a rough compass sketch adjusted to latitudes observed with a 3-inch theodolite. The route from Banissa across the lake valley is from a compass traverse by Dr. Drake Brockman. The route followed by Captain Condon's party from the Omo through Walamo to Addis Abbaba was surveyed by Corporal Carter without the assistance of fixed points. He deserves, I consider, great credit for this useful piece of work. The inevitable closing error has been proportionately distributed between the fixed terminal points. The same course has been taken with the sketch of the route through Kaffa and Jimma.

In the Rudolf districts and to the west, much of Major Austin's work has been embodied, adjusted to points fixed by triangulation. Captain H. Kelly, R.E., has also given me permission to show the compass sketches made by him in 1907–09, from Gore to Anderacha and from Wallega to Jimma adjusted between points fixed by Major Austin and myself.

THE GEOGRAPHY OF NORTH-EASTERN BAHIA.*

By JOHN C. BRANNER.

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Introductory.—A study of the geology of north-eastern Bahia and of Sergipe and Alagoas, carried on during the last eight months of the year 1907, has thrown much light upon the geography, and the geographical development of that portion of Brazil. The work was originally undertaken at private expense and for purely scientific purposes, but by order of Dr. Miguel Calmon, at that time Brazilian Minister of Public Works, Prof. O. A. Derby, the chief of the geological survey of Brazil, was authorized to contribute to the expenses of the expedition. This co-operation on the part of the Brazilian Government made it possible to extend the work far beyond what my limited private resources would permit. Dr. Argollo, the lessee of the Estrada de Ferro do São Francisco, has also most cordially and effectively co-operated in the work. Others to whom I am especially indebted for cordial and helpful co-operation are Dr. José Gonçalves da Silva of Jaguararý, Sr. Annibal d'Oliveira and Joaquim Cavalcante of Villa Nova, Sr. Leonidas Gonçalves Torres of Joazeiro, Dr. Alencar Lima, lessee of the Estrada de Ferro Central, and last but not least, Mr. Robert Brown of Bahia, who kindly looked after the shipping of collections and has shown me every possible kindness.

In the field work I have been ably and cheerfully aided by Roderic Crandall, my former student and assistant, who went with me from Stanford University. To him I am especially indebted for observations on the region along the eastern border of the state of Bahia and upon portions of the interior of the state of Sergipe that I was unable to visit personally. H. E. Williams, assistant of the Brazilian Survey, has also contributed valuable information regarding the details of the region along the Rio São Francisco between Joazeiro and Chique-Chique, and on the Serra do Assuruá, and the lower part of the valley of the Rio Verde. In the country examined, the hospitable people have everywhere done all in their power to help on the work.

For some four months we devoted our attention exclusively to the study of the area between the Serra de Jacobina and Rio São Francisco. It is a region of serras with flat catinga-covered * plains between; through these vast forests there are but few trails. In spite of the fact that it is a region of great natural fertility, it is but thinly

* *Catinga*, or more properly *caatinga*, is of Tupý origin, and is the name applied to the stunted scrubby forests of the dry interior of Brazil.

populated, owing, no doubt, to the great scarcity of water over most of the area during a considerable part of the year. We often travelled all day without seeing a single human habitation. We were obliged to carry our food with us all the time, and to carry water most of the time. We were absolutely without maps in this portion of our work, and with no other guidance than such directions as we could obtain from the few people living in the region. The routes followed were determined as far as possible by the geology and geography, but the lack of roads and the absolute impossibility of penetrating these vast catinga forests without them, made travel in many places quite out of the question. Only on special occasions did we open paths to ascend certain mountain peaks or to reach points of special importance.

Our first comprehensive view of this wonderful region was from that splendid outlook, the peak of Sant' Anna near the city of Bomfim.* Looking westward from that point in favourable weather one sees a great blue sea of mountains and valleys, apparently without system or order, covered by an interminable and impenetrable forest, and at the time of our visit, burnt up with the all-consuming drouth. But on entering this region, and as the work progressed, these serras, peaks, ridges, and valleys seemed to fall into their proper places in the great structural system that gradually yielded to our studies and unfolded itself before us.

I am often asked if the trip was not a very difficult one; if I did not suffer many hardships and inconveniences from heat and cold, from sun and rain, hunger and thirst; if these endless parched catingas with their burning sands were not dreadfully monotonous. To tell the truth, I do not know—I do not remember. Possibly such temporary inconveniences added a bit of flavour to the work, but if so, they were like the spicy odours of the catinga forest itself—pungent, alive, and invigorating. In the midst of so much that is new and of such surpassing scientific interest and importance, these trifles fade away entirely, or they serve only as a background against which the matters of scientific and human importance only stand out the more boldly.

The present paper must be regarded as preliminary. It contains only a very brief outline of some of the geographic results obtained, and subsequent work done for the Service Geologico do Brazil by Mr. Crandall and the work done under Dr. Lisboa in connection with his studies of the drouths in the adjoining regions are adding much to our knowledge of the geology and geography of all of north-eastern Brazil.

The Area studied.—The area covered by these studies embraces the south-western corner of the state of Alagoas, that is, the trough lying between Penedo and Maceio; the greater part of the state of Sergipe, and nearly all of that part of the state of Bahia lying between the Rio São Francisco and the city of Bahia, and as far south as the Estrada de

* Or Villa Nova. See note at p. 143.

Ferro Central, and as far west as Chique-Chique on the Rio São Francisco.

This area is especially interesting on account of its containing representatives of a wide range of geologic formations. Indeed, it is quite possible that we have here representatives of all the geologic formations in Brazil, though unfortunately, owing to the absence or non-discovery of fossils, the ages of most of the older rocks have not yet been certainly determined.

This area is all the more interesting from its being in the region periodically affected by disastrous drouths, and where a knowledge of the geology is of great importance in connection with the question of underground water supplies. Parenthetically, I may remark that the geology shows beyond the shadow of a doubt that an abundance of underground water can here be had over large areas that have hitherto been regarded as hopelessly without water, or where, if water was known to exist, the people did not know how to get it.

Lack of Maps.—The lack of a trustworthy detailed map of the region has greatly retarded the work. Dr. Theodoro Sampaio has published an excellent map of the Reconçavo da Bahia region, but it covers only a small part of the area we wished to study. The only one available was a map of the state published by Dr. Argollo in 1892. This map is on a scale of one to two millions—quite a small one for our purposes, but still the best there is of the kind, and, in spite of its necessory defects, we found it very helpful.

Original Map-work.—Reduced thus to the necessity of making our own maps on which to place the geology, we at first, in the region east of the Estrada de Ferro do São Francisco, made a sketch-map based upon distances between towns, villages, and estates. Later, however, we made horseback and compass meanders of all our roads, and, in addition, triangulated to the prominent points along our routes, and sketched in the bolder topographic features. From many points we also took the bearings of peaks and prominent points in the serras, and of any and everything else that could help us construct a desirable map. In this way we actually surveyed by horseback meanders a total distance of about 3000 kilometres. On these trips we also carried aneroid barometers, and records have been kept of altitudes over all the routes traversed and all the mountains ascended. Our observations in this particular area number over 400 readings.

The map accompanying this paper has been constructed by using the co-ordinates determined along the Rio São Francisco by Van Ryckervorsell; the local details of that river are from Halfeld. The coast-line is taken from the hydrographic charts, and the locations of the prolongation of the Estrada de Ferro do São Francisco is taken from the map published in Dr. Argollo's report in 1892, while the other railway locations are taken from Dr. Argollos's map of the state.

The routes followed and meandered across Bahia by Dr. Theodoro Sampaio in 1879–80 furnished a contribution of great value both geographically and geologically.* The remainder of the data used in the construction of the map were collected by the author and his assistants. Necessarily there are many gaps and defects in the work, and upon many points on which we expected to find information gathered by others it has failed us.

I cannot refrain from remarking just here that much geographic data of great value has been collected by engineers sent to explore for and to locate railways, and to express my profound regret that such important geographic information collected, often with great effort and at great expense, appears not to have been preserved, or if preserved, it cannot be found and turned to account.

The Mountains.

Serro do Espinhaço (so called).—There is a widespread idea that a serra known as the Serra do Espinhaço crosses northern Bahia from somewhere in the vicinity of Lençóes past Morro do Chapeo, Jacobina, Villa Nova, and so on to the falls of Paulo Affonso. In 1906 Dr. Derby published a paper on the Serra do Espinhaço,† which is accompanied by a map showing what was supposed to be its general location. But Dr. Derby, being an extremely cautious man, hesitated to show the Serra do Espinhaço crossing the region east of the São Francisco railway. As a matter of fact, the elevated region south-west of Villa Nova,‡ which is probably what is meant in geographic literature by the "Serra do Espinhaço," comes to an end near Villa Nova, or, as will be seen on the map, the Serra de Jacobina at that point makes a sharp bend toward the north-west. There is absolutely no mountain or suggestion of a mountain range running from Villa Nova in the direction of Paulo Affonso. The altitude of the highest point on the São Francisco railway is 683 metres at Tanque do Paulista. This is generally supposed to be the crest of the Serra do Espinhaço in a mountain pass. It is nothing

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* It is remarkable that Dr. Sampaio's paper, one of the most valuable contributions ever made to the geography of Bahia, should not have been published by any of the geographical organizations. It was brought out by a theological school in São Paulo, in 1906, under the title 'O Rio de São Francisco' (Trechos de um diario de viagem).

† "The Serra do Espinhaço" *Journal of Geology*, vol. 14, pp. 374–401. Chicago, 1906.

‡ The town known as Villa Nova, or Villa Nova da Rainha, was made a city in 1885, and its name was changed to Bomfim. The old name, however, is the one in popular use through the interior. In its early history it was known as Jacobina Nova (see 'Spix und Martius, Reise in Brasilien,' vol. 2, p. 729). The name Jacobina Nova is still heard, but it is now applied to an undefined region lying between the Rio São Francisco and the city of Jacobina.

of the kind. As a matter of fact, the railway at this point has sidled up on the east flank of the Serra de Jacobina in order to pass the city of Bomfim and the Villa de Jaguararý that were there before the railway was built. Twenty-five kilometres away to the east, and running parallel with the railway, is a broad, open, flat-floored valley lying between the Serra de Jacobina and the Serra de Itiúba. The altitude of the watershed in this valley as recorded by my assistant, Mr. Crandall, is between 425 and 450 metres above sea-level, while the altitude at Tanque do Paulista, the high divide on the railway, is 683 metres, or 250 metres higher than the watershed in the valley to the east. These topographic features are not apparent to one passing through the region on a train, simply because the vision of a person on the train is constantly cut off by catinga forests, or by the hills close at hand that shut out a wide angle from view, and appear to be parts of some great mountain system. And as the Serra do Espinhaço has long been supposed to extend across this region, nothing is more natural than to imagine that these hills are parts of that serra.

Perhaps the best point from which one can see the geography of the region is the summit of the Pico de Sant' Anna on fazenda Amarante, 6 kilometres north of Villa Nova. This peak has an elevation of 1100 metres, and from it one overlooks the hills that obstruct one's vision from the train, and sees clearly defined the great valley lying between this and the Serra de Itiúba that stretches away to the north. There are many other peaks in this range, especially those about Catunÿ and Jaguaraÿ, from which these geographic relations can be plainly seen.

It is clear that, whatever one may think of the necessity or appropriateness of the name Serra do Espinhaço for the watershed south of Villa Nova, lying between the Rio São Francisco and the ocean, it cannot be applied to any range that passes Villa Nova in the direction of Paulo Affonso, for there is no such range.

Mountain Types.

The mountains of the region may be classified according to their structure or origin as follows:—

I. The Itiúba type, or the great granite ranges and the smaller isolated granite peaks.

II. The Jacobina type, or the quartzite ranges and the short isolated quartzite ridges associated with them.

III. The Tombador type, or the mountains, serras, and tablelands capped with a certain series of heavy, resisting, horizontal sandstones or quartzites.

IV. The diamond-bearing ranges, formed by the folding and erosion of the diamond-bearing sandstones, conglomerates, and quartzites.

V. The taboleiros or table-topped hills of soft Cretaceous or Tertiary sediments.

The Serra de Itiúba Type.*—The Serra de Itiúba seems to be made up entirely of granites. Its southern extremity is a short distance south of the railway station of Itiúba, and from there it bears almost due north, and ends about 25 kilometres south-west of Patamuté. It has an average width of from 1 to 3 or 4 kilometres, an elevation of about 500 metres above sea-level, and a total length of 175 kilometres. Everywhere it rises abruptly from a flat catinga-covered granite plain. It is the only true serra of any considerable size and length lying between Villa Nova and the falls of Paulo Affonso.

Belonging to serras of this type are many of the mountains to be seen along the line of the Central railway between Bandeira de Mello and Tapéra, and in the region both north and south of that portion of that railway. There are less important and still smaller peaks of granites, gneisses, and crystalline schists over the area of crystalline rocks south and west of the prolongation of the São Francisco road, and a few to the north and east of that line. In the north-eastern part of the state of Sergipe and in all of that part of Alagôas lying north of the area of sedimentary rocks the serras belong to this Itiúba type.

In outline the granite mountains vary greatly, but they commonly have rounded summits, and their sides often exhibit concentric exfoliation. Around their bases are frequently many rounded boulders of decomposition, but there is usually but little talus about their bases as compared with what we are accustomed to see in temperate regions. Generally these granite ranges are not as well watered as the serras of sedimentary rocks. The regions of granite serras are therefore mostly thinly populated areas in the states of Bahia, Sergipe, and Alagôas.

The Jacobina Type.—The Serra de Jacobina, locally known as the Serra dā Saude, Serra da Santo Antonio, and by various other names, and also supposed to be a part of the hypothetical Serra do Espinhaço, is the finest range of mountains in the state of Bahia, and one of the finest in all Brazil. It is a high, well-defined, north-south range, with a low country on both sides of it. About its base on both sides and in the valleys within the range are considerable forests, but the summit extends above the timber-line, and is covered with wiry grass.

The Jacobina range, taken as one type of the serras of the region, is made up chiefly of quartzites, conglomerates, and unctuous schists. Several complete sections across this serra have been examined, and at all of these places it exhibits the same general structure. Usually the beds are tipped up nearly or quite on end, and dip toward the north-east or south-east. The extremely hard quartzites alternate with soft and easily eroded schists, and the whole, rising on end from a rather flat granite floor, gives the mountains a strong topographic contrast, both with the region around them and within themselves. The

* The name of this serra is sometimes given as Tiúba ('Spix u. Martius, Reise,' vol. 2, pp. 731–734, 747; 'Hartt's Geology,' etc., p. 319).

accompanying geologic sections exhibit the structure of this range at places which may be regarded as typical.

Sections across the entire range at seven different places, some of them widely separated, show that there are four fairly well defined parallel ridges in the group. The valleys between vary considerably in depth, but they are usually narrow. Sometimes there is a fifth ridge, but in such cases it generally merges into the other ridges at one end, while the other stands further and further out until this spur dies down on the plain. Near the city of Bomfim the north-eastern direction of the south end of the serra changes to a north-west direction.

Attention is also called to one of the most striking facts connected with the Serra de Jacobina, and that is, that the drainage that flows westward from the crest of the range turns sharply about and flows through the serra at several points. This peculiar feature will be referred to again. On account of these peculiar deep-cut gaps, roads cross the serra without the necessity of climbing over its summit.

High, old, and rugged, rising abruptly from and overlooking the great plains to the east, cut by its own drainage, and spent by geologic cycles

Section showing the general geology and topography along Rio Agua Branca, near Campo Formoso.

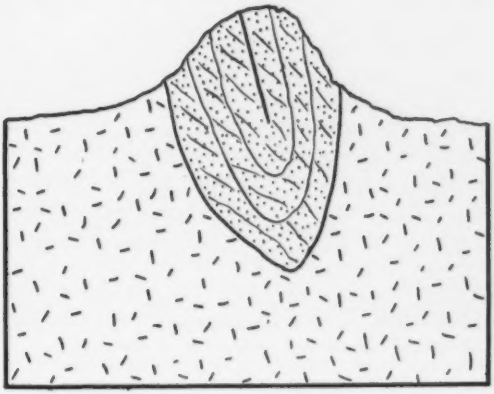
of erosion, the great Serra de Jacobina is the mountain range *par excellence* of the entire region. From its flanks have been carved the sediments to make many of the newer beds that lap, or have lapped, against its base. It was formerly much higher than it is at present, but its height is still so great, and it stands in such sharp contrast with the region to the east, that its summit and sides receive a much greater precipitation than the surrounding regions. As a result, it has perennial streams, and a much larger population than one would otherwise expect.

It is evident that the existence of the Jacobina range and most of its topographic features are due to its being made of highly resisting beds of quartzite standing nearly on edge, while the country on both sides is of granites or other crystalline rocks that decompose and break down more easily than do the hard beds of the serra.

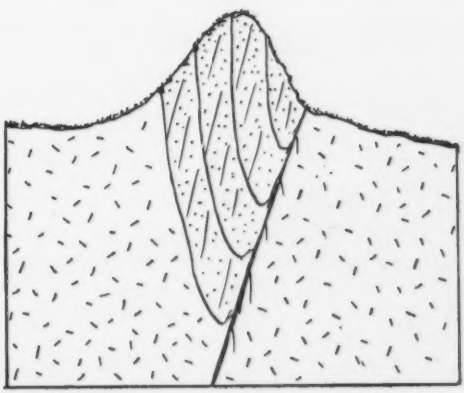
There are many smaller mountain ranges and peaks of somewhat similar geologic structure over the granite regions east of the Serra de Jacobina. One of the most noteworthy of these inferior quartzite ranges is the Serra da Curralinho at Angico. That serra is some 15 kilometres in length and about 700 metres high. It is formed chiefly by a single bed of flinty white quartzite that stands practically on end. In places the sides of this bed are exposed by the removal of the

adjoining strata, and this gives the white appearance so characteristic of the range as seen from the railway on the west.

In the wide valley east of the Serra de Curralinho are a few other smaller ridges and peaks of similar constitution. The peak at Monte



Section across a quartzite ridge to show the structure on the theory of its being a remnant of a synclinal fold.



Section illustrating the structural relations of the ridges of vertical quartzites on the theory of their being faulted into the older granites.

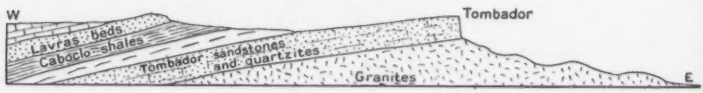
Santo is likewise of quartzite, but the high peaks east of that town are of granite. Most of the minor peaks that rise above the general level east and south of Villa Nova are similarly of quartzite. The Serra do Botiquim is one of these. South of Missão Sahy are still other quartzite ridges.

The genetic and structural relations of the quartzite ridges and peaks to the granites of the surrounding plains is not certainly known at present. The only theories that suggest themselves are that they are probably remnants of the oldest sediments of the region thrust into the granites by faulting, or that they are left as the last remnants of synclinal folds in rocks that rest upon the granites.

It is an interesting and striking fact that the conglomerates found in the Serra de Jacobina are composed of pebbles of quartz and of quartzite. I have examined many of these conglomerate beds confident of finding granite boulders in them, but instead I have found in them not a single piece of granite that could be identified as such.

This can only be explained by the fact that when the conglomerates of the Jacobina range were being formed, there must have been near at hand an older sedimentary series of rocks from which these quartzite boulders were derived. Possibly these smaller quartzite peaks are older than the Jacobina range, and were the source from which the conglomerates were derived. If so, the small quartzite ridges are the last surviving remains of the earliest sediments of this region.

Sketch of the east face of the Tombador range from Genipapo, 12½ miles south of Jacobina, and looking north-west along the face of the escarpment. The round hills in the foreground are granites and gneisses underlying the Tombador sandstone that forms the escarpment



Structure of the Tombador range west of Jacobina.

The Tombador Type.—The Serra do Tombador is not a serra in the ordinary sense of that word, but it is the edge of a plateau whose beds dip gently beneath the Salitre valley that lies west and north-west of it. The apparent elevation of this plateau is produced by the removal along its east face of the yielding rocks on which the escarpment-forming beds rest. This will be readily understood from the accompanying sketch, which shows the topography, and from the diagram, which shows the general structure of the Serra do Tombador anywhere west of the city of Jacobina.*

The Tombador beds are hard sandstones, quartzites, and conglomerates, with a maximum thickness of about 400 metres. These beds seem formerly to have extended quite across the intermediate valley, and to have rested

* The geology of the region is described by the author in *Amer. Journ. Sc.*, vol. 33, pp. 335–343, November, 1910.

THE TOMBADOR SANDSTONE BLUFF, JUST BELOW SALITRE FALLS.

LOOKING SOUTH-WEST ALONG THE COAST 12 MILES NORTH-EAST OF JEQUIÁ DA PRAIA, STATE OF ALAGÔAS, BRAZIL. THE ROCKS OF THESE CLIFFS ARE THE MESOZOIC SEDIMENTS THAT FORM THE TABLELANDS OF THE INTERIOR.

against the flanks of the Jacobina range. The serra do Tombador, as it now stands, is therefore the protruding and resisting edge of a bed in process of removal, and the mere remnant of what it was originally.

At its southern end it first disentangles itself from the topographic intricacies some 20 kilometres east of Morro do Chapeo, where it overlooks the valley of the Rio Jacuípe. It follows down the left of that stream for about 40 kilometres toward the east where the river cuts the range in a deep steep-sided gorge some 47 kilometres north of the mining town of Campinas. From this gap the Serra do Tombador takes a course of about N. 20° E. North-east of Ventura, and where it is cut by Rio Jacuípe, and also along all this part of the range to and north of Jacobina, it has an elevation of about 940 metres. Everywhere it has the same general character and structural features, that is, it is the lofty precipitous edge of a plateau whose beds dip gently westward beneath the Salitre valley. Following the Tombador range toward the north, however, it becomes less and less prominent as a mountain range, and before the latitude of Campo Formoso is reached it has disappeared as so bold and striking a feature of the landscape; though it recovers its topographic importance further north. Geologically it can still be traced northward, usually marking by the way the eastern margin of the Salitre valley. Nearly west of Bomfim the margin of these Tombador beds swings westward, and, keeping parallel with the Jacobina range, it next appears as a prominent topographical feature in the vicinity of the Caxoeira do Salitre on the lower Rio Salitre, some 35 kilometres south of Joazeiro. The falls of the Rio Salitre are made by the river passing over the hard quartzites of these Tombador beds, apparently in the trough of a great syncline.

West of the Salitre river the Tombador beds again become prominent topographic features. They form the summit of the Serra da Cruz and of the Serra do Mulato—the two flat-topped mountains visible from Joazeiro and some 30 kilometres south-west of that city. The Serra do Mulato has an elevation of 865 metres, and as it rises from the flat valley of the Rio São Francisco on the north, it is one of the most striking topographic features of that region. Geologically it has the same structure as the great Tombador range near Jacobina; its base is of granites and other old crystalline rocks, while its summit is made of an approximately horizontal series of very hard flinty quartzites and conglomerates. These quartzites form the steep vertical walls more than 100 metres high that run round three sides of the Serra do Mulato. From the top of the serra one can trace with the eye the edge of the quartzites through the Serra do Boqueirão and into the summit of Serra da Cruz, two mountains immediately to the south-east.* Further up Rio São

* For the details of the geology and geography of this mountain, see "The Geology of the Serra do Mulato, State of Bahia, Brazil," by J. C. Branner, *Amer. Journ. Sci.*, October, 1910.

Francisco this same series of quartzites forms in the same way the flat summits of the Serra de Encaibro, Serra do Tombader, and of other minor serras along the right bank of the river below Chique-Chique. The geologic structure and the topography of the region north and west of Rio São Francisco suggest that these same Tombador quartzites occur on that side of the river. That area, however, has not yet been studied.

The Diamond-bearing Ranges.—The next beds above the Tombador quartzites that are topographically prominent are those forming the Lavras series of Derby—a series of pinkish, false-bedded quartzites and conglomerates which yield the diamonds and carbons. These rocks are the ones that form, help form, or cap nearly all of the prominent mountains of the diamond regions of Bahia. The beds have been pressed laterally so as to form gigantic folds, and these folds have been eroded off and otherwise attacked by the agencies of denudation until we have the present topography. The topographic prominence of the Lavras series is due partly also to the fact that it rests upon the Caboclo beds, a thick series of clay shales. The sections across the diamond-bearing beds given at pages 25 and 26 show clearly the relation of the rocks of the Lavras series to the topography.

The diamond-bearing beds make either entirely or in part the following prominent mountains in the diamond regions north-west of Lençóes: Serra da Barra de Mendes, Serra de Gonçalves, Serra Grande; Serra da Mangabeira, Serra de Muribeca, Serra de Assuruá, same range; Chapada Velha, Serra das Lavras Diamantinas, same range.

It is worthy of note that many of the serras are anticlinal in structure, while others are formed by the breaching, or the removal of the central portions of anticlines. In general structure the great range at, and for a long way south of, Morro do Chapeo is simply a broad anticlinal fold.

The diamond-bearing beds have been found to extend far north of what was hitherto supposed to be the limits of the diamond region. They even form the north slopes of the Serra da Pedra Branca along the south side of Calmon valley, and they appear also in the mountains north of that valley. The edges of these same beds make or cap the prominent peaks to the south and south-east known as Angelim, Cascavel, Annibal, Cambão, Caboclo, Pico Nabuco, Corredor, and Curralinho.

They also form the high Bautista range north of Morro do Chapeo; they cap the mountains about Gruna, Rodelleiro, and Alagoinhas; and they form the mountain known as the Morro do Chapeo and many similar peaks in the vicinity of the town of that name. South of Morro do Chapeo they form only the western flank of the main serra to where it joins the Lavras ranges north of Lençoes. It also forms a part of the eastern flank of the mountains as far south as the village of Antonio José. The diamond-bearing serras are thus among the high mountains

of the interior; indeed, they make up the bulk of the elevated diamond region known as the Chapada Diamantina.

Where denudation has removed the diamond-bearing beds, the underlying Caboclo beds are exposed. Over much of the diamond district these Caboclo beds form the surface rocks. Farther north, especially about the east end of Calmon valley and along the base of the serra at Gruna and Rodelleiro and through the central portion of the range south of Morro do Chapeo, the Caboclo beds form the mountain masses in spite of the fact that the mountains are commonly capped by the hard diamond-bearing beds. Indeed, the topographic prominence of the diamond-bearing beds in the Jacobina Nova country is largely due to the softness of these underlying Caboclo shales.*

The name Caboclo, taken from the Caboclo peak on the east side of the Almas valley, was given these beds by the writer as a field name in 1907. There is some doubt about its standing, for in August, 1906, Prof. Derby mentioned a series of beds beneath the diamond-bearing beds in the Lençóes district, and called them the Paraguassú series. I have not been able to identify the Caboclo and Paraguass series with certainty, but if it turns out that they are the same, the name Paraguassó will have precedence.

The Tablelands (Taboleiros) of Eastern Bahia.—The taboleiros, or tablelands, of eastern Bahia are made of soft sediments partly Tertiary and partly Cretaceous. The area covered by them is shown on the accompanying map, and need not here be described in detail. For the most part these sediments are nearly horizontal, but in places they have been considerably folded. In the region around the bay of Bahia they are well exposed at many places on the beaches, where erosion by the waves has brought out the structure beautifully. This folding is more or less characteristic of these sediments all along the eastern side of the bay of Bahia, and continues toward the north-east to and beyond the city of Alagoinhas. It is a matter of interest in connection with the geographic development of the state that the axes of these folds run north-east—south-west, parallel with the coast just north of the city of Bahia.

Following these soft sedimentary beds northward away from the coast, they are found to be less disturbed in the interior than they are along the coastal belt. North of Geremuábo, however, the beds are more or less horizontal across nearly the whole plateau belt, but along their eastern margin they are bent sharply upwards. This bend can be traced almost to the Rio São Francisco at Jatobá. The undisturbed horizontal beds are exposed even close to the city of Bahia, and there are many fine exposures on the Alagôas coast where the ocean has encroached upon them.

* "The Serra do Espinhaço, Brazil," by Orville A. Derby, *Journ. Geol.*, vol. 19, p. 386, July, August, 1906. Chicago.

This zone of horizontal soft Mesozoic sediments does not attain a high altitude, but it nevertheless forms one of the broad topographic features of the state of Bahia. It has an average width of 75 kilometres, and an elevation of about 450 metres above tide-level. Where denudation has not been active the region covered by these beds is flat, its soil is clayey and hard, the vegetation stunted, the zone is destitute of streams, and is but sparsely populated. Where erosion has cut into the taboleiro beds they have left the margins of the plateau falling off gradually to the surrounding plains with a few more resisting points left as outliers. The thickness of the beds can be seen at some places; but at other localities, as along Rio Vasa-Barris east of Canudos, where that stream has cut through the plateau sediments, the maximum thickness cannot be seen because their base is below the level of the stream channel.

These taboleiro beds are now the mere remnants of the original deposits. They formerly extended landward far beyond their present limits. Their outliers on the Pernambuco side of the Rio São Francisco show that they once covered much of that region, and that they probably connected with the beds forming the Serra do Araripe on the southern frontier of Ceará. To the west they appear to have reached the Serra de Jacobina. In Sergipe they probably originally covered all the northern portion of that state, and in Alagôas they extended far north of the margin marked on the accompanying map as sedimentary.

On account of their low relief, these plateaus receive less rainfall than the higher region to the west. A region that is rather dry under ordinary circumstances is liable to suffer greatly in times of drouth, and such is the case with this plateau country. There is, however, much more water in the taboleiro region than is commonly supposed. If deep wells were put down in the valleys near Bom Conselho and Mirandella, and at many other places throughout the taboleiro belt, it is believed that an abundance of good water could be obtained for domestic use.

(*To be continued.*)

GEOGRAPHY IN THE ENCYCLOPÆDIA BRITANNICA.

Probably none will welcome the new edition of the 'Encyclopædia Britannica' more cordially than geographers. Not only is their own subject vast, and the difficulty of keeping up to date well nigh impossible, but they have to turn again and again to articles on other subjects of which they must know something before they can proceed with their own investigations. These articles, by no means the least useful to the geographer, will not be noticed here, but only those more strictly geographical in subject matter will be reviewed.

The subject is vast enough. We expect to find in this Encyclopædia

the most complete and well-proportioned account of it in our language. It should contain the latest and most reliable information as precisely and succinctly condensed as possible, every map and illustration that will elucidate and concentrate in graphic form the gist of the text, a weighty summary of current views on all kinds of geographical problems, and a very full critical bibliography. It may be said at the outset that, with a few remarkable exceptions, with which we shall deal later, these points have generally been kept in mind. The new edition is much more valuable than the old one, and, even if parts of the supplement to the ninth edition reappear, they have been revised or incorporated in such a way as to be more useful than before.

In such a vast and complete work it is necessary at the outset to read and to review the articles according to some plan other than the naïve alphabetical arrangement still retained in the 'Encyclopædia Britannica,' an arrangement which, we venture to think, is best reserved for an index volume. We may group them as follows:—

I. The scope and method of the subject.

II. The earth as a whole and its more important parts—land, water and atmosphere.

III. The chief divisions of its surface and their geographical characteristics

IV. Information of a descriptive and statistical character, including the applied aspects of geography.

V. History of geography and biography of geographers.

VI. Geographical notations and the way in which they are employed in the Encyclopædia.

I. The articles on geography in successive editions of the 'Encyclopædia Britannica' form a clear record of the growth not merely of our knowledge of the globe but of the ideas and methods which dominate the geographer. If we turn back a century to the fifth edition, we find geography defined as "that part of knowledge which describes the surface of the earth; its divisions, extent and boundaries; the relative position of the several countries and places on the globe, and the manners, customs, and political relations of their inhabitants. Geography may be conveniently divided into, descriptive geography, or that part of the science which describes the forms, limits, extent and variety of surface of different countries, with the manners and customs of their inhabitants; and *physical* geography, or that part which teaches how to determine the situations of different places on the globe, and to lay down and delineate the positions for the information of others. Descriptive geography is the more popular and entertaining part of the subject. It is usually divided into ancient and classical geography, geography of the middle ages, and modern geography." . . . "Physical geography is properly a branch of mixed mathematics, and its principle depends on geometry and its kindred sciences, trigonometry and perspective."

The article is divided into Part I. history and present state of geography (7 pp.), Part II. principles and practice of geography (47½ pp.), and an appendix (1½ pp.) on the teaching of geography. Part II. comprises a long account of globes and how to use them, and a shorter one of maps, and little more.

When we compare this with Dr. Mill's article we realize what a change has come over the world, and that immense as has been the growth of detailed knowledge due to a century's exploration, it is no greater than the growth of our conception of the subject, its principles and its applications. The science of geography is no longer a matter of exercises on the globes and propositions in applied geometry, trigonometry and perspective. Nor is it purely descriptive, though that may still be the most popular and entertaining part. We finish Dr. Mill's article feeling that geography is a great and weighty subject; presenting problems recondite as well as of popular interest; which has a history of scientific effort as well as of human adventure which must stir every one who reads it; and that it has a practical significance in the affairs of people which is seen to be more important and subtle the more it is investigated. It is a noble science necessary to those who would be adepts in the art of government, as well as in many other arts; and it is safe to prophesy that its importance will become better recognized in the present century even than it has been in the past.

Dr. Mill's general article is in essentials a reprint of that in the supplement to the last edition. It is divided into three sections: (1) The History of Geographical Theories; (2) The Progress of Geographical Discovery; (3) The Principles of Geography. It is difficult to conceive a better condensed or more readable article in the space allotted to it. The accounts of the progress of theory and of exploration are marvellously well done. The section on principles is open to some criticism for which the author is probably not responsible. Interpolated in it is a very brief, much too brief, account of geomorphology, and a briefer and even more inadequate one on anthropogeography. Both should have been dealt with as oceanography and climatology are, merely with the briefest remarks, or as biological geography is discussed in less than a page, with references to special articles on oceans, climate and sections in the articles on plants and geology.

We are sorry Dr. Mill perpetuates the misleading term mathematical geography for astronomical geography. Mathematics can be applied to any aspect of geography where the facts can be sufficiently simplified to be represented in mathematical notation. Dr. Mill might have said more about the growth of synthetic geography, especially in the past decade, which is transforming the subject from an examination of distributions, to a scientific study of environments. The failure to recognize this, it will be shown later, has marred the proportions and treatment of many important regional articles.

II. There are special articles dealing with the geodesy, climatology, and oceanography, which are good examples of well-condensed writing. But there is no article on geomorphology or land form other than the two somewhat overlapping sections in the general articles on geography and geology which have to satisfy the student. This might be excused if proper attention had been paid to the different types of land forms in special articles. We search in vain for articles on coasts, or valleys, or plains, though we find pages devoted to plant or animal types. Surely coasts are as important as cœlenterates. Islands need not have been dismissed in a jejune article of half a column, while an order of the animal kingdom receives several pages. Some smaller articles are equally unsatisfactory, and are of no scientific value, *e.g.* that on watersheds.

Biological geography is dealt with under Distribution of Plants and Zoological Distribution. In both articles the floral and faunal aspects are very properly discussed in detail, and though there is a useful section on plantecology, the important distribution of associations of plants and animals is practically ignored.

III. The descriptions of different regions differs greatly. The continents are well done, and some of the larger states are discussed in full, well-proportioned and well-documented articles. England and Wales, the United States, Brazil are among the articles which are models of clear condensation without omitting any essential points. As a rule, the geological part of these articles is the work of a geologist, and some attempt has been made to trace the evolution of the main morphological divisions. Here and there other specialists, *e.g.* botanists, ethnologists, have written other sections of general descriptive articles. This is all to the good, provided that the geographical co-ordination of the whole is attempted, but, except in certain articles, this is lacking, or is very inadequately done.

In some cases, where it has not been attempted, the obviously careful conscientious work which the writers have put into their articles leads to the conclusion that they were quite oblivious to the need of it. In France, for example, the physical features stand out so clearly that they form one of the most fascinating studies for the geographer. Further excellent works exist dealing with the country as a whole, and with its *pays*, so that the material for making even a detailed study of it is abundant. In the Britannica the physical features are discussed under the misleading title physiography in half a column, in which the essential elements are not even mentioned, and their characteristics never hinted at. In the article on Germany there is a longer catalogue of names, but an almost equal obliviousness of the fundamental physical conditions.

IV. In looking through the gazetteer part of the work we find a remarkable and accurate summary of such facts as are selected, and we cannot but admire the ability of the writers and the careful supervision of the editors. The misstatements and misprints are very few indeed, and

we feel that we can accept with confidence such facts as are given. The selection of articles is most reasonable, and we think that only a very carping critic will fail to be satisfied with this part of the work, except on one point—that is, the bibliographical one.

There are a number of bibliographies in various articles which are ample; but in a great many more they are quite inadequate, and in most of these there are few or no critical notes. This is a grave defect. A full, well-arranged and annotated bibliography is as important as the article which summarizes the work of the leading authorities.

Besides being unequal, the bibliographies, and in many cases the statistics, have not been brought up to date (*e.g.* Coal Statistics of British Isles are for 1903, old editions of standard works cited, etc.), which might quite well have been done, as we understand the typoscript was not set up until the last year or so.

One element of bibliography essential for the geographer is omitted from the regional articles, *i.e.* references to the standard maps of all kinds. For these it is necessary to turn to the general article on maps. Here some repetition might have been allowed, or else a note should have been put to refer to the map.

It is rather a pity, from the point of view of statistics, that the publication of the work was not delayed a year, in order to make use of the 1910 and 1911 census of different counties. From this point of view the work is already out of date.

V. The pleasing and popular history of exploration is one of the best sections, and if here and there we read a biography, and wish for fuller details, we have, as a rule, only to turn to the articles on scenes and the discoverer's work to find them. This is certainly the happiest way to prevent undue repetition.

VI. The article on maps is admirable, as far as it goes. Dr. Ravenstein has written succinctly about the history of maps, and Colonels Clarke and Clare have prepared an account of map projections, which is much more complete and satisfactory than the inadequate article in the ninth edition. When, however, we look for a discussion of the methods of statistical or distributional mapping, we cannot find it, though the fact that such maps exist is mentioned. These matters are quite as important as map projections.

So it is throughout the whole work. The maps of the different continents and countries are usually shaded in brown to show relief, and have many names and political colourings. Such maps are necessary, and those in the new edition are excellent of their kind, for which, after the atrocious productions considered sufficient for the supplement to the ninth edition, we are duly thankful. There are also a number of black and white geological maps, and here and there a contour one. No continent or country, however, is adequately mapped in this edition.

In spite of a certain profusion of pictorial illustrations, in articles on

other subjects, these have been omitted from the geographical ones. Yet such pictures are as important in geographical articles as in others.

To conclude, we have in the new edition of the 'Encyclopædia Britannica' the best gazetteer and the most adequate collection of articles on geographical subjects in our language. Though we have dwelt on its deficiencies, its nineteenth century scrappiness in places, and its neglect of important aspects of the subjects, its inadequate bibliographies, and still more inadequate illustrations, this must not be taken to mean that we do not recognize that it is a great advance on any other work in our language, and that it is a monument of erudition and careful editing, which on most matters can be trusted to give the best information in a clear and satisfactory manner. A. J. H.

THE FLOWING WELLS OF CENTRAL AUSTRALIA.*

By Prof. J. W. GREGORY, D.Sc., F.R.S.

VI. The Difficulties of the Water Pressure Theory.

(*a*) *The Limitations of Water Pressure.*

If the wells are not now maintained by annual inflow, but are discharging accumulations of residual water, of water due to ancient infiltration, and of water from a plutonic source, what is the cause of their overflow? There are probably three factors at work, of which water-pressure is doubtless one. Water in the lower end of an inclined tube or sheet of water is necessarily under pressure from that at a higher end, and if the water be flowing it is under hydraulic pressure, and if the water be stationary it is under hydrostatic pressure.† Water in any inclined bed is necessarily under a certain amount of hydraulic or hydrostatic pressure. But the friction on water moving through fine tubes or fine-grained rocks places a definite limit on the distance to which this pressure can act in uplifting water. The friction of the passage of water through the fine pores of rocks at a rate sufficient to maintain a large flow from the wells soon absorbs the pressure due to head.

Mr. Knibbs has replied that I have exaggerated the retarding effect of friction owing to having overlooked the slow rate of movement that would suffice to maintain the discharge from the wells. Mr. Knibbs's paper was issued in reply to the report in the Australian Mining Standard of a few remarks made during the course of a lecture at Bendigo on the formation of ore deposits. Mr. Knibbs's paper was published by the Royal Society of New South Wales in 1903, so that I might have been expected to have read it before writing on the question in 1905. The volume was, however, not available to geologists in this country until long after that date.‡

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* Continued from p. 59. Map, p. 232.

† When water is moving so slowly that it is practically stationary the conditions are generally described as hydrostatic.

‡ I had examined the last volumes of that journal available, and I still happen to have the application slip for that volume returned "not received" when I applied for it in 1905. The librarians at the British Museum (Nat. Hist.) and at the Geological Society have kindly told me that the volume for 1903 was not received by them until

Mr. Knibbs explains the slow movement of the water that would suffice to maintain the wells by a formula,* which is a mathematical expression of the fact that the diameter of a big circle is much larger than that of a very small one, Mr. Knibbs's formula † is so simple that it would prove too much, for, as he says, the discharge from a bore drawing water from a wide area would be maintained by a movement of the water so slow that it might be regarded as almost infinitely small and therefore frictionless. If so, and if Mr. Knibbs's formula were an adequate expression of the facts, the loss of head should also be infinitely small; but the loss of head is admittedly considerable, as is obvious from the isopotential map of any large artesian basin or to the ordinary "plane of head" of subterranean water.‡

In spite of Mr. Knibbs's formula, water percolating through the minute cavities in porous rocks is unquestionably greatly retarded by friction § and other factors. Mr. Knibbs's formula, like others, is of no practical value when applied to great distances and to water which sinks so deep below the earth's surface that its temperature is greatly raised. Many formulæ have been given, showing the loss of head due to the frictional resistance encountered by percolating water. The standard formula at present is Hazen's, and the loss of head in loose deposits of various grades and at various rates of flow according to that formula are shown in the table on the following page.||

That table may be useful as showing the different loss of head in various loose sediments, and it must be remembered that the effective porosity of such materials is materially reduced when they are consolidated into firm rocks.

Mr. Knibbs's formula might, however, have been very useful to Mr. Pittman if it had prevented his oversight of the importance of velocity on the retardation by friction of the flow of water. To illustrate the power of friction on flowing water I quoted from Box's "Hydraulics," a case in which the mere roughness of the inside of a one-inch pipe held back the water to an extent equal to a loss of

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August, 1908. If the Royal Society of Sydney only sends its journal to the standard British libraries five years after publication, it is not surprising if its papers do not receive the attention they deserve.

* $V = \frac{vr}{R}$, in which r = radius of bore, R distance of point considered from the centre of the bore, v = velocity at the bore, V = velocity at the distance R. (*Journ. R. Soc. N. S. Wales*, vol. 37, p. xxix. 1903).

† Mr. Knibbs's calculations based on this formula have been disputed by G. W. Grabham, who says that the results are twelve times too large ("Notes on some Recent Contributions to the Study of Desert Water-Supplies," *Cairo Sci. Journ.*, vol. 4, p. 170. July, 1910).

‡ I am glad to find that Mr. Knibbs agrees with me upon the practical question at issue. He remarks that it "may be fairly inferred from what he [*i.e.* myself] says, viz. that the supply may be exhausted" (p. xlvii.); and that "we may be recklessly playing with an economic capital which it has taken centuries to accumulate." Every bore, he concludes, not utilized should be shut down (p. xxxii.).

§ Professor David, though an advocate of the water-pressure theory for the Australian wells, remarks on the limitation imposed by "the vast frictional resistance which would be offered by the beds of fine sand which would have to be traversed by the artesian water," (T. W. E. David, "Notes on Artesian Water in New South Wales," *Journ. R. Soc. N. S. Wales*, vol. 27, p. 427. 1893).

|| Hazen's original paper being somewhat inaccessible, reference may be made to its explanation by Slichter, "The Motions of Underground Waters," Water Supply Papers of the United States Geol. Surv. No. 67, pp. 22–23. 1902.

head of 700 feet in 100 miles. Mr. Pittman correctly quoted the data, including the statement that the one-inch pipe was discharging a gallon a minute; but he denies the possibility of this case, because the artesian wells in Paris have a loss of only 136 feet, instead of 700 feet, in 100 miles. He entirely overlooks the factor of velocity. The one-inch pipe in question and spaces of equal size in the Paris sands would only lose head at the same rate if the water were flowing through the latter at the rate of a gallon a minute through each circular inch.

TABLE OF LOSS OF HEAD IN SILT, SAND, AND FINE GRAVEL.

Velocity.	Effective size of grains.		Temp.	Distance.			
				1 mile.	10 miles.	50 miles.	100 miles.
	inch.	mm.	° Fahr.	feet.	feet.	feet.	feet.
1 yard per day.	0·001 (coarse silt)	0·025 clay or	50	7·0	70·5	353·0	706·0
			100	3·85	38·5	192·5	385·0
			150	2·65	26·5	132·0	265·0
,,	0·005 (fine	0·125 sand)	50	0·28	2·8	14·0	28·0
			100	0·15	1·5	7·7	15·4
			150	0·11	1·0	5·0	10·6
,,	0·03 (coarse	0·75 sand)	50	0·008	0·08	0·4	0·8
			100	0·004	0·04	0·2	0·4
			150	0·003	0·03	0·15	0·3
,,	0·15 (fine	3·75 gravel)	50	0·0002	0·002	0·01	0·02
			100	0·0002	0·002	0·009	0·017
			150	0·0001	0·001	0·006	0·012
5 yards per day.	0·001	0·025	50	35·0	352·0	1765·0	3530·0
			100	19·0	192·5	962·5	1925·0
			150	13·0	131·6	658·0	1316·0
,,	0·005	0·125	50	1·4	14·0	70·6	141·0
			100	0·8	7·7	38·5	77·0
			150	0·5	5·0	26·5	53·0
,,	0·03	0·75	50	0·04	0·39	2·0	4·0
			100	0·02	0·21	1·1	2·2
			150	0·015	0·15	0·7	1·5
,,	0·15	3·75	50	0·001	0·01	0·07	0·155
			100	0·001	0·01	0·045	0·085
			150	0·0005	0·005	0·03	0·06
20 yards per day.	0·001	0·025	50	141·2	1411·0	7059·0	14180
			100	77·0	770·0	3850·0	7700·0
			150	53·0	531·0	2654·0	5307·0
,,	0·005	0·125	50	5·6	56·5	282·0	565·0
			100	3·1	30·8	154·0	308·0
			150	2·1	21·0	105·0	211·0
,,	0·03	0·75	50	0·16	1·6	7·8	15·7
			100	0·08	0·86	4·3	8·6
			150	0·06	0·58	2·9	5·9
,,	0·15	3·75	50	0·004	0·04	0·25	0·5
			100	0·003	0·04	0·18	0·34
			150	0·002	0·02	0·12	0·24

Mr. Pittman also fails to appreciate the difference of flow in pipes or large channels and that in pipettes or porous rock. He replies to the view that friction would absorb the head of the water in a long passage through sandstone by the statement that the loss of head is as the square of the velocity, and misquotes me as supporting that statement. I cited two formulæ to explain the flow of water in pipes and pipettes,* and Mr. Pittman quotes the wrong one. He applies the rules for the flow of water in large pipes to its flow through porous rocks; the

* 'The Dead Heart of Australia,' p. 303.

formula for pipettes should have been adopted and it shows that in them the loss of head varies as the velocity, and not as the square of the velocity.*

(*b*) *The Irregularities in Potential Level.*

The fundamental difficulties in explaining the flowing wells of Central Australia by water-pressure are the irregularities in the level to which the water rises and the irregular distribution of the flows. The hydrostatic theory is expressed by the well-known dictum that water will find its own level; and in U tubes or in water pipes under the uniform conditions of a city supply, water does find its own level; but the conditions which control the flow of water through a variable series of rocks are so complex that I know of no area where water does find its own level at a great distance from its intake. "The plane of the water head" is always a slope. Even under the conditions most favourable to the free circulation, the water does not rise to its own level in wells 100 miles from the intake. Thus in Dakota the potential level 20 miles east of the Black Hills is at 3000 feet; it falls 1200 feet in the first 170 miles to the east, or 6½ feet in the mile, and then 200 feet more in the next 130 miles, or 1½ feet in the mile.†

The water level in a well or the level to which the water in a flowing well would rise in a pipe placed over the mouth, is its potential; lines and surfaces drawn through points where the potential is at the same height above sea level are the isopotential lines and surfaces.

If the conditions be absolutely hydrostatic, then the isopotentials form a level surface; if the conditions be hydraulic, then the isopotential lines occur on a slope, which need not be uniform in grade but would always be downward from the intake.

The water-pressure theory is inconsistent with the water rising, either above the level of its intake, or above the level of the lowest outcrop of the intake bed, unless, in the latter case, the frictional resistance to the passage of the water from its entrance to the low-lying outcrop is greater than that from its entrance to the water-level in the wells. The isopotential maps of the Australian flowing wells‡ show that there are many cases in which the potential rises away from the assumed intake bed, while the distribution of areas of high and low potential are quite inconsistent with the theory that the water is absorbed by the Blythesdale Braystone or the Jurassic sandstones and flows through them under the central basin. The section issued with Mr. Pittman's "Clarke Lecture" from Brisbane, through Toowoomba and Longreach to the Gulf of Carpentaria, also shows that the potential surface varies irregularly and exceeds the level of the eastern margin of the supposed intake. Thus the potential surface is below 1100 feet between Dalby and Canobie; it rises to 1300 feet near Morven, and falls to 1200 feet at Charleville, and to 900 feet at Longreach, thence continuing north-westward the potential rises to over 900 feet between the Darr river downs and Sesbania, and thence sinks towards the Gulf of Carpentaria. It may be argued that the two rises in potential along this line are due to water coming from secondary sources of supply, in beds outcropping to the north-east of the line of section. That

* Williams has given two curves of supply for Queensland wells, and remarks that the flow varies as the head, and not as the square root of the head, as would be expected on the ordinary theory (*Min. Proc. Inst. Civ. Eng.*, vol. 159, pp. 319–321. 1905).

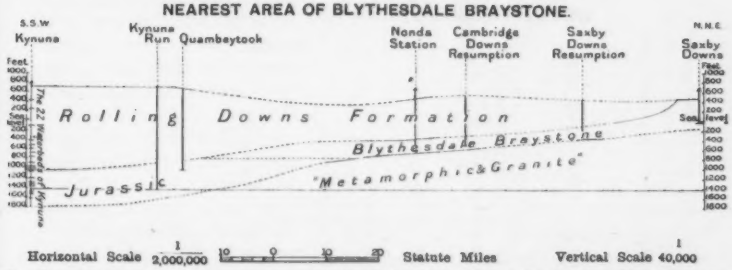
† Map in Darton's 'Preliminary Report on the Geology and Underground Water Resources of the Central Great Plains,' Dept. of the Interior, U.S. Geol. Survey, Professional Paper No. 32, pl. lix. 1905.

‡ A map of the isopotential lines is given as Map No. II, 'Dead Heart of Australia.'

explanation is, however, difficult on Mr. Pittman's view that the Jurassic sandstones are the intake, for these rocks do not extend so far to the north-west, and do not approach within 70 miles of Charleville; and if there be a secondary intake from beds at a high level north-east of Charleville, the flow from it should be south-eastward towards the area of Jurassic sandstones near Toowoomba instead of the assumed flow in the reverse direction.

Professor David and Mr. J. Baillie Henderson have both pointed out that the rise of the water in some of the wells could not be explained by hydrostatic pressure. Thus Professor David * remarked in 1893 that the water at the Charleville well would rise to the level of 1197 feet, which, he says, is "about equal to the level of the intake," 140 miles away; and Mr. Henderson pointed out in his annual report for 1893-4 that the water in this well would rise to 1198 feet above sea level or higher than the Cretaceous intake beds except at a few points.† To explain this anomaly, Professor David made a suggestion which he dismissed as "extremely doubtful." And, as a matter of fact, even if the

DIAGRAMMATIC SECTION, KYNUNA TO THE NEAREST AREA OF BLYTHESDALE BRAYSTONE.



The Braystone which is supposed to feed the wells is at a lower level than the discharge, and water itself overflows from the Braystone in wells on the Saxby Downs.
The section at Nonda is taken after Cameron. Ann. Progress Rep. Geol. Survey, Queensland, 1900, pl. II.

FIG. 7

supposed intake beds rise at one place to 1200 feet, they have a free discharge to the surface near Roma, at 987 feet, *i.e.* level with the surface of the ground at Charleville. Why should water in a bed of sandstone at the height of 1200 feet force water by either hydrostatic or hydraulic pressure to the same height at a place over 100 miles away, while there is a free outlet near at hand at 1000 feet. Again, Professor David remarks that the water of the well at Cunnamulla would rise to the level of 1008 feet (or perhaps 1100 feet), although it is 220 miles from its assumed intake, the Blythesdale Braystone near Roma; and that bed outcrops at the level of only 1065 feet at Hodgson, west of Roma, and of 987 feet at Blythesdale, east of Roma, and for a width of 7 miles past Pickanjennie and Wallumbilla it is at the level of a little over 1000 feet.‡ So the water that flows into the Blythesdale Braystone in the Roma district rises 200 miles away in the

* T. W. E. David, "Notes on Artesian Water in New S. Wales and Queensland," Part II., *Jour. R. Soc. N. S. Wales*, vol. 27, p. 426. 1893.

† The potential level, according to Mr. Henderson's Tables, 1908, is 1161 feet, so it has fallen somewhat.

‡ The levels of the two railway stations on the Blythesdale Braystone there are 1019 and 1032 feet.

wells of Thargomindah, Bando and Cunnamulla, to the levels of 1048, 1071 and 1100 feet, or to a greater height than the outcrop of the intake bed near the entrance of the water! The water rises not only to its own level, but exceeds the level at which it might freely escape from the assumed intake.

Again in northern Queensland, the surface level of a flowing well at Kynuna is 655 feet above the sea, and the water would rise above it to the level of 722 feet; the level of the nearest outcrop of Blythesdale Braystone at Saxby Downs 120 miles away (see Fig. 7), is given by Henderson * for one place as 496 feet. Why should not the water escape at Saxby Downs, instead of at level 128 feet higher, at a locality 120 miles distant? Moreover, the Braystone has a continuous outcrop descending northward from Saxby Downs till it is only 100 feet above the sea.

If it be replied that the wells of the Kynuna district are not fed by the northern area of Blythesdale Braystone, then it is admitted that the area of that rock,

SURFACE LEVEL AND POTENTIAL LEVEL OF WELLS FROM LONGREACH TO COREENA.

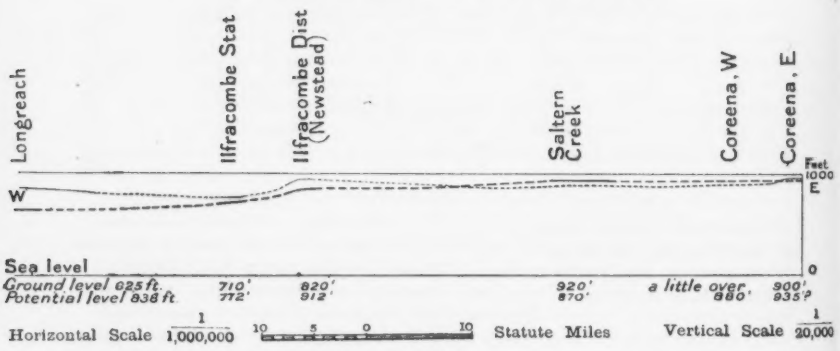


FIG. 8

which is larger than all its other outcrops together, does not contribute to the flowing wells, and we are driven back to the smaller areas, 250 miles away, or to Jurassic sandstone 800 miles away, which are inadequate for the areas nearer them.

The Kynuna well can hardly receive its water from any of the more southern outcrops of the Blythesdale Braystone. The nearest of them are at Jericho and Aramac, where the water has a potential of only 800 feet; and they are separated from Kynuna by an area with a potential of over 900 feet. The only area on the water-pressure theory in which to look for the source of the water would be that of high potential around Hughenden; but that area is covered by basalts with some Desert Sandstone. It is true that in Mr. Gibb Maitland's map † of 1898 some exposures of the Blythesdale Braystone are shown rising on the edge of the schists of the Cape gold-field to the height of 2198 feet; but those outcrops are assigned to the Desert Sandstone in the two latest geological maps of the

* Tables, 1908, p. 27.

† A. Gibb Maitland, 'The Delimination of the Artesian Water Area North of Hughenden,' Geol. Surv. Queensland, 1898.

area, the Geological Sketch-map of Queensland, issued in 1905, and the Geological Map, issued by the Water Supply Department in 1908. The high-level Braystones that might once have been appealed to for the supply of the Kynuna well, have been removed from the maps.

Again, in the district near Barcaldine, the wells show numerous instances of a rise in potential away from the intake, and of wells ceasing to flow while others nearer the intake continue their discharge. Thus, as is shown in Fig. 8, the potential rises from Saltern creek going westward to Ilfracombe, and again from Ilfracombe continuing westward to Longreach. The same phenomenon is shown in the section (Fig. 9) from Brisbane to Cunnamulla.

Another similar case is the steady increase of gradient on the south-western border of the area; the water will only rise to about 300 feet a little north of the north-western corner of South Australia, while further to the south-west, at Goyder's Lagoon, 150 miles further from the supposed intake, the water will rise to 600 feet. In that area there is no Blythesdale Braystone, the country is lowlying, and the rainfall almost the scantiest in Australia; so that it appears idle to appeal to any existing local addition from the present rainfall.

The increase of potential to the west is in agreement with the greatly increased flow from many of the western wells; and, as was remarked to me by Mr. B. L. Schooley, the manager of the Intercolonial

SECTION FROM CUNNAMULLA TO BRISBANE SHOWING THE DEPTH OF A SERIES OF WELLS, THE RELATIONS OF SURFACE AND POTENTIAL LEVELS AND THE POSITION OF THE CHIEF WATER-BEARING BEDS.

The levels at Corio, Fernlea and Sixty-five Mile are approximate. The only well at Mona, of which surface and potential levels are recorded, is 20 miles south of the section line; it and its levels are therefore shown in dotted lines.

Water bearing Beds

FIG. 9

Deep Well Boring Company, the occurrence of many wells with enormous flows to the west of wells with much smaller flows is difficult to reconcile with the supposed flow from east to west.

Mr. Pittman makes no attempt to explain these anomalies except by remarking that the levels in Queensland have been determined only by aneroid, and are therefore so unreliable that no argument can be founded on them. Many of the wells, however, are situated beside the three railway lines which traverse Queensland from east to west, so that their heights are quite reliable; while the heights of the wells away from the railways were doubtless determined by reference to the nearest railway level. Full confidence may be felt as to the sufficient accuracy of the levels along the Queensland railway lines, and the irregular variation of pressures in wells of which the heights are reliable is sufficient to show that the water-pressure theory does not explain the facts.

The evidence obtained in the last five years confirms the isopotential lines previously drawn. For example, Mr. Schooley tells me that so far as his experience goes, the course of the isopotential lines, as shown in 1905, is correct. They will no doubt be modified in detail, especially in areas where wells are still few; but the fresh information confirms their substantial accuracy. Mr. Pittman remarks that the effort to use the isopotential lines is like fitting together the pieces of a picture puzzle. It is a picture puzzle in which, on the water-pressure theory, the pieces will not fit.

In the alternative theory of the flowing wells of Australia the pieces fit satisfactorily and the anomalies are readily explained. There are two high-pressure areas in Queensland on the north-eastern side of the area of flowing wells; and they are both areas of widespread volcanic activity in geologically recent times.* One of the high-pressure areas is to the north-west of Hughenden in a district where the geological surveys by W. H. Rands and A. Gibb Maitland have shown the existence not only of widespread sheets of basalt, but of ten extinct volcanic foci (see Fig. 10).†

The second high-pressure area lies to the south-west of the basalts from Mount Hutton through the end of the Carnarvon Range, the Buckland Tableland and Mount Faraday to Mount Playfair. Some of the basaltic outliers to the south-west of this basalt tableland probably cover the vents of the old volcanoes. The high potential in these areas of former volcanic activity is a natural consequence of the higher temperature that may be expected in the subterranean waters.

The irregularity of the isopotential lines in Australia offers a most instructive contrast to those of South Dakota, as shown by Mr. Darton's map of that area, of which part is reproduced as Fig. 11. In Dakota, as would be expected on the water-pressure theory, the lines are regular and at right angles to the main direction of flow, and show a steady fall from the intake to the outlet. If the isopotential lines in eastern Australia were as consistent with the requirements of the hydrostatic theory, it would probably not be called in question.

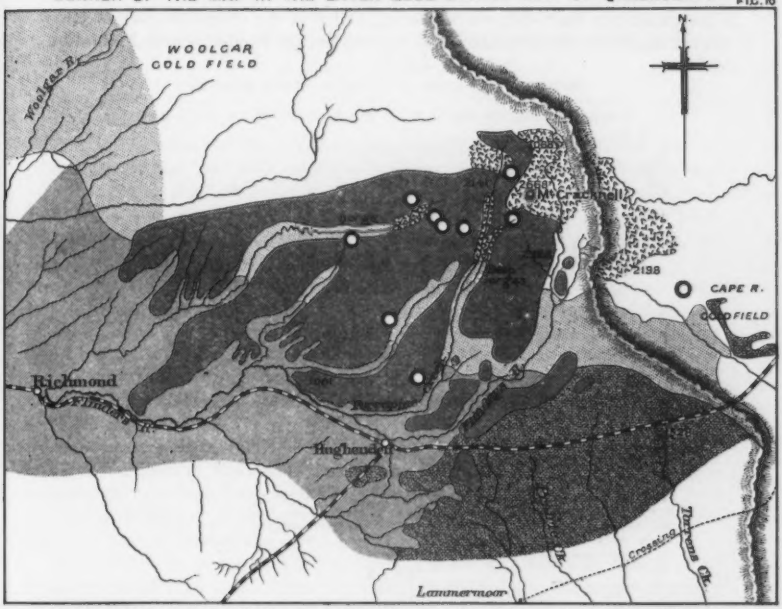
The geological conditions and the loss of head in wells flowing from water-pressure are very different from those of Queensland. The case with the smallest

* The date of the basalts of the Darling Downs is represented on the official maps as Trias-Jura, from the asserted interstratification of the basalts with those rocks. Being impressed by their Cainozoic aspect, I asked Mr. B. Dunstan (the Government Geologist of Queensland) as to their age, and he informed me that they, in his opinion, overlie Cainozoic beds.

† Mr. Rands' map was issued in 1891. The number of volcanic foci is confirmed by Gibb Maitland's later map of 1898, part of which is reproduced as Fig. 10.

loss of head collected by Mr. Pittmar is that of the St. Peter Sandstone in Wisconsin, and Kentucky, where it is ·67 foot per mile. In these States, as in South Dakota, the conditions are most favourable to percolation. Thus, A. R. Schultz describes the St. Peter Sandstone in Wisconsin as a "soft incoherent rock, of large well-rounded grains of quartz;"* and this porous rock is interbedded between the magnesian limestone and the Galena-Trenton limestone, which is 200 to 300 feet in thickness, and is traversed by many cracks and fissures. The account of the St.

GEOLOGY OF THE EASTERN MARGIN OF THE ARTESIAN AREA NEAR HUGHENDEN AFTER MAITLAND (1898) SHOWING THE DISTRIBUTION OF THE EXTINCT VOLCANIC VENTS IN THE AREA OF HIGH POTENTIAL. THE DESERT SANDSTONE IS EXTENDED IN THE S.E. CORNER OF THE MAP IN THE LATER GEOL SURVEY MAP OF QUEENSLAND. FIG. 10



*The later maps include all but the outcrop in the N.W. corner in the Desert Sandstone

Peter Sandstone in other states, given in the same series of memoirs, shows that the St. Peter Sandstone retains these characters and conditions over a wide area. In Iowa it is described by W. H. Norton † as "a bed of incoherent quartz sand, which, because of its freedom from clays and cementing material, and because of the phenomenal roundness of its grains is an exceptionally important water horizon." Its thickness is about 100 feet and in Iowa also it lies below the

* 'Underground Waters of Eastern United States.' U.S. Geol. Surv., Water-Supply Paper, No. 114, p. 236. 1905.

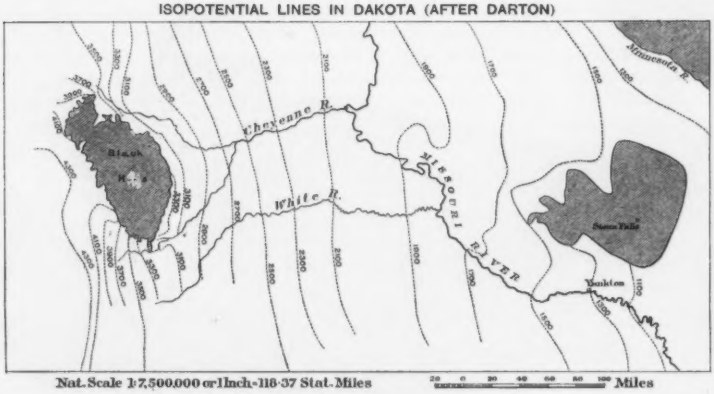
† *Ibid.*, p. 223.

porous Galena-Trenton limestone. The catchment area on the edge of this rock is described by Norton as of great width owing to its gentle dip.

Water percolating through loose porous rocks or flowing through wide channels or spaces, such as caves, large fissures or large joints, suffers but slight loss of head. In the London basin the head is maintained, not by water percolating through the actual chalk, but through fissures, and if a bore does not strike a fissure it fails. When a large supply is wanted from the chalk, a well is dug and galleries are driven from the bottom in order to expose a large collecting surface and strike many of the contributing fissures.

In Queensland the conditions governing the subterranean passage of water are different. It is usually admitted that the Blythesdale Braystone extends but a comparatively short distance westward, and that the water-bed may be either sand or sandstone interstratified with the clays of the Rolling Downs Formation;

ISOPOTENTIAL LINES IN DAKOTA (AFTER DARTON)



N. H. Darton. Preliminary report on the Geology and underground water resources of the Great Central Plains. U.S. Geol. Survey Prof. Paper No. 32. Washington, 1905, pl. LIX.

The whole area is underlain by the Dakota Sandstones except in the three outcrops of older rocks shown by the tinted areas.

FIG. 11.

according to Mr. Pittman, in some cases the water comes from the Carboniferous rocks which have no high-level eastern intake area in Queensland. As Dr. Jack pointed out, the water must be flowing through the rock and not through fissures, or more of the bores would have been barren. The bores occasionally find water in beds of quicksand or soft crumbly sandstone; and the bore records show that some of the wells obtain their water from thin bands of sandstones, which have no very long horizontal extension. In South Dakota the water bearing layer is one vast sheet of sandstone. In Australia the water comes from thin disconnected seams of sandstone, which, it is obvious from the bore records, are not continuous from the wells to the eastern outcrop of the formation.

The flowing wells in Central Australia agree not with those of the simple type of South Dakota in which the upflow is due mainly to hydrostatic pressure, but with the more complex type in such areas as Idaho and south-eastern Oregon, the outflow of which, as Mr. I. C. Russell has shown, is due to subterranean heat. Mr. Russell has pointed out that the flowing wells in that basin discharge

from water-bearing beds, which derive their supply partly by the percolation of meteoric water from the surface, and partly from hot waters which rise through fissures into the permeable beds (Fig. 12). Mr. Russell distinguishes the water from the two sources by their temperature.

Fig. 12

Russell's Diagram of an Artesian Basin charged with water from Below.

(c) *The Toowoomba Sandstones as a High-pressure Reservoir.*

The fall in potential level of the wells in south-western Queensland was explained by the early advocates of the water-pressure theory as due to the existence of an outlet to the Great Australian Bight, to which the water is flowing. Hence the loss of potential is the necessary deduction for hydraulic head. The assumed outlet to the Southern ocean has been universally abandoned, and Mr. Pittman has therefore to find another. Two outlets are possible, one to the Pacific near Brisbane, and the other to the Gulf of Carpentaria. The Brisbane outlet would be no use to Mr. Pittman's theory, and that there is no great discharge through it is shown by the small quantities of water in the Ipswich mines and the slight flow of 8000 gallons a day from the well, 1781 feet deep, at the Brisbane racecourse. Mr. Pittman has therefore to maintain a great discharge from south-western Queensland over the rim of old rocks below Manfred Downs into the Gulf of Carpentaria.

In order to maintain this flow he requires (1) a high-level collecting ground, which he assumes in the Jurassic sandstone (Trias-Jura) at Toowoomba; (2) a powerful flow through those sandstones first westward and then northward, over the Manfred ridge; (3) the continuity of the water-bearing strata through this long and sinuous course.

The facts seem to me opposed to each of these requirements. There is no doubt a tract of land at Toowoomba reaching at one point to the height of nearly 2000 feet; but as has already been pointed out, the area of sandstones at this level is small, and the rocks are not well placed for a storage reservoir, since they are tapped on the east by the Toowoomba escarpment. We are not dependent on mere probabilities on this point, as two facts show that the Jurassic sandstone at Toowoomba do not act as a high-level pressure reservoir; (1) the well in these sandstones at Dalby, to the west of Toowoomba, which has been bored through these sandstones to the depth of 2500 feet, yields a flow of only 25,675 gallons a day;* (2) and instead of the area to the west and south-west of Toowoomba being a high-pressure area, it is occupied by the largest gulf of low pressure in Queensland.

The small yield of the Dalby well and the dryness of the Jurassic sandstones in the well at Albilbah, show that the main supply to the prolific flowing wells further west, does not come from the Jurassic sandstones of Toowoomba.

Mr. Pittman's third requirement, the continuity of the water-bearing layer,

* 'Henderson's Tables,' p. 2. 1908.

is disproved by an overwhelming mass of evidence. Thus the water-bearing bed at Muckadilla, according to Mr. Pittman (Clarke Lecture, pl. viii.), is "Permo-Carboniferous" and not Jurassic. The Kynuna wells show that the water from the flowing wells is not derived from beds which outcrop on the assumed eastern intake; and this fact is also shown by wells which derive part of their supply from the old rocks which form the rim and floor of the artesian basin. Mr. Pittman confirms the fact that the water from the Oxton well is obtained from a fissure in the granite, but he suggests that it is derived from the overlying sandstone; and the well at Glenormiston, to the west of the artesian basin, obtains a good supply with the water-level standing only 4 feet below the surface,* although bored through the older Palæozoic rocks into granite.† The significance of these cases is that the water—even if meteoric in origin—does not pass through one continuous water-bearing layer as in a typical artesian basin, and the analogy with water under the steady pressure of a stream flowing between impermeable layers becomes inapplicable.

The flow over the northern rim of the artesian basin would have to be considerable ‡ to allow of any appreciable movement of the water in the central basin, for the central area of flowing wells is 1000 miles wide, and the outlet to the north is limited to a line of 150 miles long. Moreover, in central Queensland, the wells are fed from the depth of 3000 feet below sea-level, and in south-western Queensland and South Australia from 4500 feet below sea-level; yet the rim of the basin near Manfred Downs is less than 300 feet below sea-level.

Mr. Pittman has reproduced my section from the Gulf of Carpentaria to Charleville and continued it to the sea at Brisbane, in order to show that the intake areas near Toowoomba would supply sufficient pressure to maintain the circulation of the water in the deep central basin. The section, as thus extended, is reproduced as Fig. 13, with some additions and modifications in Mr. Pittman's part of it, viz. (1) the insertion of the Pickanjennie and Brisbane wells; (2) the deepening of the Muckadilla well; (3) the insertion of the basalts on the summit of the plateau near Toowoomba; § (4) the "Blythesdale Braystone," marked by Mr. Pittman in the Roma well has been connected to the outcrop of that formation shown on the Queensland survey map; (5) a dotted line in Mr. Pittman's map at Toowoomba is apparently intended to represent the base of the "Triassic Sandstone"; I have added another line which seems to me to represent that position more correctly, showing its passage eastward to beneath sea-level. The older rocks outcrop in places around Brisbane, but the Jurassic (Trias-Jura) Sandstones are nevertheless represented on the Queensland survey map as having a continuous outcrop from Toowoomba to the sea.

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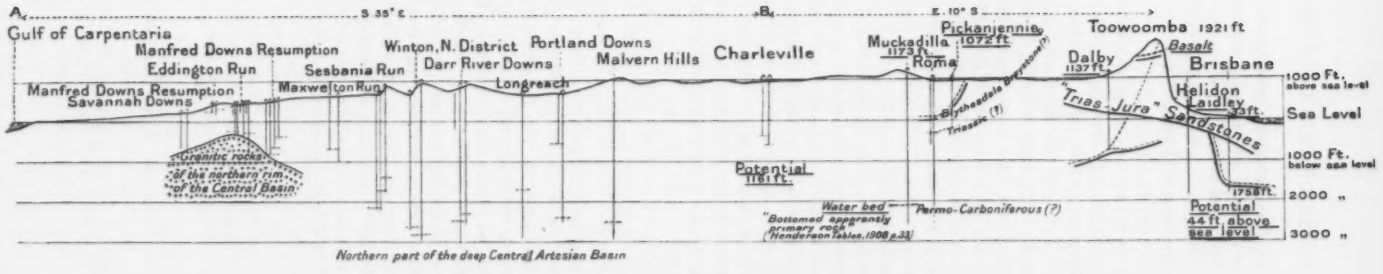
* 'Henderson's Tables,' p. 19. 1908.

† A section of the well is given by Jack, "Stratigraphical Notes on the Georgina Basin, with reference to the question of Artesian Water," *Proc. R. Soc. Queensland*, vol. 11, Part II. 1895. Separate copy, p. 2.

‡ Although Professor David at that time accepted a southern outlet for the artesian basin, his view of the practically stagnant nature of the water in the central basin of southern Queensland may be inferred from his remark that "in its central portions, at all events, the basin behaves like a sealed basin, and the pressure of the water in the central portions of it is therefore probably more hydrostatic than hydraulic," T. W. E. David, "Notes on Artesian Water in New South Wales and Queensland," Part II. *Journ. R. Soc. N. S. Wales*, vol. 27, 1893, p. 427.

§ Readers of Mr. Pittman's remarks, 'Clarke Lecture,' p. 127, on his section (pl. viii.) would infer that the summit of the highlands at Toowoomba is formed of the sandstones.

SECTION FROM THE GULF OF CARPENTARIA TO TOOWOOMBA.



Northern part of the deep Central Artesian Basin

Horizontal Scale $\frac{1}{10,000,000}$ 100 50 0 100 Statute Miles Vertical Scale $\frac{1}{50,000}$

Flowing wells. ↑↑ Water-bearing layer. ----------

From A to B the section is reproduced from the "Dead Heart of Australia," p. 305; from B to Brisbane was added by Mr. Pittman.

The lines names and notes underlined in the eastern part of the diagram, are added to Mr Pittman's sections

FIG. 13

Mr. Pittman's part of this section illustrates several interesting facts which do not help his theory that the water at Toowoomba exerts a high pressure on the water beneath Charleville, 350 miles away; for the potential level at Charleville is 1161 feet, and it is only 900 feet at a locality 100 miles from Toowoomba on the line along which the pressure should be exerted in order to influence the districts around and beyond Charleville.

Again, just east of Roma, according to the Queensland Geological Survey, there is an outcrop of the Blythesdale Braystone at a lower level than the ground at Charleville, where the potential level is 1167 feet; and the potential of the well at Pickanjennie, 20 miles east of Roma, is only 1072 feet or 95 feet lower than it is at Charleville, which is 170 miles further down the hydraulic grade.

The upper part of the Pickanjennie well, according to the survey map, is in the Blythesdale Braystone,* which appears to contribute but little water to it, as the chief water-bearing bed is at the depth of 1420 feet, and therefore well within the Jurassic; and although the Dalby well, which goes through the whole of that formation, has the small flow of 25,675 gallons, the Pickanjennie well, which only enters the upper part of the formation, yields 177,680 gallons a day. The significance of this fact is that, in order to prevent the Jurassic sandstone draining through the Toowoomba escarpment and the Ipswich area eastward to the Pacific, it must be assumed that the formation is divided into water-tight layers by sheets of shale dipping westward. If so, the water bed of the Pickanjennie well would get its supply from only the western end of the Jurassic area, which, I understand, is at the level of only about 1200 feet above the sea. In that case any pressure exerted in the direction of the central basin from Toowoomba would have to pass well to the south of the Charleville-Dalby line and through the area of lowest potential.

(*d*) *Oscillating Wells.*

Another striking phenomenon in connection with these wells, for which the water-pressure theory gives no explanation, is their occasional tidal oscillation. The best known of these wells is at Urisino. Mr. Pittman placed a tide gauge on it, and his observations show that as the tidal period varied from time to time, the movement cannot be a lunar tide, as it is in many oscillating wells.†

I duly considered the possibility of explaining the oscillation in the Urisino well by a wave action on a subterranean current producing a kind of water hammer; but no solution on that line seemed possible. I was therefore driven to the view that this interesting well was affected by variations in gas-pressure like a periodic geyser. Mr. Pittman rejects this explanation and has misunderstood my statement about the well, for he remarks ('Clarke Lecture,' p. 124) that "the suggestion made by Gregory that the phenomenon may be due to escape of

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* The well section ('Henderson's Tables,' 1908, Well Section, No. 210) does not support this determination, and thus suggests a further reduction in the area of the Blythesdale Braystone. The bore passed through 404 feet of shale immediately between the surface deposits.

† Mr. Pittman says there is only one tidal well in New South Wales, and that the statement that the Ninety-one Mile Bore also shows tidal variations is a mistake caused by a confusion of localities, which his readers would infer was due to me. The statement that the Ninety-one Mile Well has a tidal rise of 4 feet every four hours I quoted from a published report by Professor David. In addition to Urisino, there are tidal wells in Queensland and others which increase in activity at irregular intervals.

carbonic acid cannot be endorsed," and he goes on to say that there is no evidence there of carbonic dioxide. But I was careful to point out that "we do not know enough about the water in the Urisino well, for any reliable suggestion to be made as to the precise cause of its oscillations" ('Dead Heart of Australia,' p. 330). I suggested that the Urisino well "probably belongs to the same category as the well at Jaude," in which the movement is due to the escape of carbon dioxide. The oscillation at Urisino may be due to some other gas; but that the well belongs to the same category as that at Jaude appears to be still the only explanation of its movements. Mr. Pittman offers no other. The water-hammer hypothesis, which might be reconciled with the hydraulic theory, appeared so inadequate and untenable that I did not think it worthy of mention.

In addition to this periodic movement, some of the wells show oscillations, which are probably due to a true tide or to variations in barometric pressure. Thus Mr. Graham Hewett * tells me that at Cunnamulla the well shows slight alterations in pressure, which are highest at full moon; they therefore, as he justly remarks, indicate a tide due to a lunar influence. The well at Boatman, I am told, flows most powerfully at midday; this increase may be due to the diurnal atmospheric tide. Mr. John Alexander, the headmaster of the school at Longreach, whose house is immediately opposite the bore, remarked to me that the well must vary in pressure, as its roaring is much louder at some times than at others. According to Mr. Henderson ('Tables,' 1908, Well Section, 208), one of the water-bearing beds in the Dalby well gives a "pulsatory flow."

Mr. W. E. Miller, manager of the Coreena station, has supplied me with an interesting record of a phenomenon at well 7 upon that station, which appears inexplicable on the water-pressure theory, but presents no difficulty if the flow be due to gas-pressure. The well was sunk in 1898, and for a time discharged 100,000 gallons a day. In 1900 the flow ceased after having been very small for some time; Mr. Miller dropped a stone down the well in order to determine the level of the water, which immediately began to flow again. The discharge continued for a month or so, and then stopped. Mr. Miller restarted it by lowering a piece of iron down the casing and pulling it up rapidly. For about a month he was able to start the well by repeating this operation once a week. Sometimes he could re-start the flow by striking the clamps with a heavy sledge hammer. In time all these methods ceased and the well is now pumped by a mill.

The flow of another well in the same district could be restarted by blowing down the bore. The restoration of flow by such slight disturbances of equilibrium can be more easily explained by a variation of gas-pressure, analogous to the eruptions of a geyser caused by throwing turf into it, than by a change in so steady an influence as water-pressure.

The Hon. E. W. Lamb kindly tells me that an increased flow has been observed in some of the wells of New South Wales at times of low barometric pressure. The increased flow from springs when the barometer is low is a well-known phenomenon which has been established, for example, by the work of Mr. Baldwin Latham, near Croydon. The increase is no doubt due to gas pressure, the gases dissolved in the water expanding when the atmospheric pressure is reduced. Mr. Latham's evidence therefore shows that gas-pressure acts even on wells, of which the flow is mainly determined by ordinary water-pressure.

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* Letter, September 6, 1909.

VII. The Causes of the Ascent of the Water.

(*a*) *Gas Pressure.*

Though the hydrostatic pressure of adjacent water no doubt helps the ascent of water up the wells, the irregularities in the water-level and its oscillation show that other factors are also at work. One of the most important is gas-pressure, due to the tension of gases imprisoned in the heated water. The entrance of heated plutonic water into the water-bearing layers acts somewhat like the air in an air-lift pump, in which the expansion of compressed air forced into a well raises the water to the surface.*

Dissolved gas occurs in many of the Queensland flowing wells. Thus at Roma the gas evolved has been used for lighting the town.† Gas is discharged with the water of flowing wells in all parts of Queensland, as is shown by Mr. Henderson's tables; and various informants have added to the known range of gas-charged waters. Thus, Mr. J. T. Hannay told me that water from his wells at Geera at first appeared milky owing to the numerous gas-bubbles. Those wells are not discharging as abundantly now as they did, and the amount of gas evolved has diminished; but as I watched them, bubbles could be seen continually rising to the surface with the outflowing water. One of the three bores at Albilbah has proved a failure, although a sudden rush of water from it was announced as the beginning of a great flow; but as soon as the gas which was rising with the water had escaped, the flow ceased.

The ascent of oil in oil-wells was at first assigned by one school of geologists to hydrostatic pressure; but that view has been generally abandoned. The spouting and overflow of the oil is now attributed to gas-pressure; and this explanation will probably be admitted as the main factor in areas where water flows to the surface at temperatures approaching the boiling point.

I was interested to find how widely spread in Queensland faith in the gas-pressure explanation has become. The water-pressure theory, I find, has been rejected, amongst others, by Sir Arthur Morgan, the Lieutenant-Governor of Queensland; Dr. J. P. Thomson, secretary of the Geographical Society of Queensland; Mr. Fysh, the secretary of the Shire Council of Barcaldine, and by practical well-borers like Mr. Hannay. Mr. Hannay advocated the gas-pressure theory between 1899 and 1902, and urged the town council of Barcaldine to adopt a policy of water administration based upon that view. His prediction that the wells would steadily diminish in flow has been only too completely fulfilled. The upholders of the water-pressure theory, on the other hand, predicted that there was no reason to fear any serious decrease in the yield of the wells. Theories as well as trees may be judged by their fruits.

(*b*) *Rock Pressure.*

The second factor which I believe helps the ascent of the water to the surface through these wells is the weight of the overlying rocks. Mr. Pittman objects that the weight would prevent the entrance of the water into the bed; but this

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* In air-lift pumps, according to some authorities, the effect is due to the lowering of the specific gravity of the water-column by the amount of air discharged into it.

† Mr. Pittman endeavours to separate this well from the others by the view that it enters the Permo-Carboniferous rocks below the Jurassic sandstones. This identification is, however, rejected by Cameron of the Geological Survey of Queensland, an expert on the Carboniferous and Jurassic rocks of south-eastern Queensland.

objection could at most only apply to the replenishment of the bed from its outcrop, and not to the inclusion of water at the formation of the bed, or to water injected into it from below.

Mr. Pittman also objects that rock-pressure would force the water from a water-bearing layer to escape along its outcrop; but the water would only escape there from that width of the bed wherein the resistance by friction to the movement of the water is less than the rock-pressure.

Mr. Pittman further objects to the efficiency of rock-pressure by an analogy with bricks in a wall. He remarks that the space left by the removal of a brick from the bottom of a wall is not filled by the bricks above being pressed downward into the cavity. But a brick wall erected on a sheet of waterlogged sand or soft clay would squeeze the plastic material away from beneath it. Every miner knows how clay on the floor of a tunnel rises slowly into it by the pressure of the walls. Is this movement due to the weight of the clay at the outcrop instead of to the weight of the adjacent rock?

Mr. Pittman's main argument against the rock-pressure explanation is an appeal to American authorities, and he quotes a letter from Mr. M. L. Fuller, saying that rock-pressure, though often advocated, has never been supported by any real evidence, has never received official sanction or been accepted by careful investigators. Since the date of that letter, Mr. Fuller has written a memoir on the controlling factors of artesian wells, amongst which he includes rock-pressure. Mr. Fuller, it should be remembered, limits the term artesian to wells in which the water rises by hydrostatic pressure. He would, therefore, refuse to accept as artesian any well flowing only by rock-pressure, which he, however, accepts as one of the various factors influencing the outflow from artesian wells. He says, for example, that "extensive sinkings of the ground have followed the pumping of water from mines and the withdrawal of the support afforded by hydrostatic pressure, indicating that the rock-pressure on the water must have been considerable, at least locally." *

Mr. Fuller adopts not only rock-pressure as an effective factor, but comparatively insignificant loads. Thus he describes the outflow from wells as affected by variations of barometric pressure and "still another result, which may be more common than is usually suspected, is the increase of pressure on confined waters, due to the plastic deformation of impervious beds under the varying loads resulting from changes in the water level of overlying streams, lakes, or the sea. This is especially noticeable in wells along the sea coast." †

Other recent American authorities on water supply, such as Veatch, also accept rock-pressure as an important factor. He even considers that the weight of a city, which must be very small in comparison with that of a thousand feet of rock, aids the outflow of water from flowing wells. There would be no such effect when a city is built upon solid rock; but the weight of a city on a sheet of clay overlying water-bearing beds, as at New Orleans and Galveston, would, Mr. Veatch remarks, affect the outflow from the wells.

A striking instance of the raising of the water-level in a well by a small load is quoted by Veatch,‡ from a record by King from Madison County, Wisconsin.

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* Fuller, M. L., "Summary of the Controlling Factors of Artesian Flows," U.S. Geol. Surv., Bull No. 319, p. 33. 1908.

† *Ibid.*, p. 32. 1908.

‡ Veatch, A. C., "Fluctuations of the Water-Level in Wells, with Special Reference to Long Island, New York," U.S. Geol. Surv., Water-Supply and Irrigation Paper, No. 155, p. 75. 1906.

The water-level in a well 140 feet from a railway line is raised by the passing of a heavy freight train.

Hence, as the extra load on the earth's surface due to a shower of rain, a flood in a river, an increase in depth of a lake, or the passing of a heavy train, may increase the outflow from wells, it is idle to deny that the weight of several thousand feet of rock resting upon a waterlogged bed of sand or friable rock would not squeeze the water into a bore-hole. Subsidences of the surface caused by the pumping of subterranean water, show that such water is under pressure from the overlying rocks. It is quite true, as Mr. Fuller says, that rock-pressure may not be a very common cause of artesian wells, for the great majority of them derive their waters from shallow beds. But Mr. Fuller's memoir now shows that this factor has received official sanction and is accepted by careful investigators.

That rock-pressure must be a powerful factor in squeezing water out of layers of soft rocks, which are deeply buried under thick masses of overlying material, may be left to the common-sense judgment of geologists who have considered the large amount of pore space present in rocks on their first deposition. The proportion of pore spaces in clays and sands is high, and the interspaces in an aqueous rock are originally occupied by water which is gradually removed from the rock by drainage, by evaporation, or by the water being pressed out by the overlying material. As Sorby remarked,* rocks which contained as much as 90 per cent. of water "may have been made almost solid by the squeezing out of this water."

All aqueous rocks are at first charged with water, and they may retain some for a prolonged period. Thus the interesting work of Lane has shown that even Cambrian clays contain residual water, from which he has estimated the salinity of the Cambrian Sea.† The rocks gradually part with their original water, and may, during contraction, discharge several times their own final volume. If, as in the case of the Australian flowing wells, water-logged beds are covered by a heavy sheet of clay, the water may be retained in the water-logged beds until some artificial outlet be made. Then the rock-pressure inevitably squeezes out the water, either slowly, if the pressure be small in proportion to the strength of the water-bearing material, or rapidly, if the water-bearing rock yields easily to the pressure.

One of the Kynuna wells may be quoted to illustrate how especially favourable are the conditions in some of the Australian wells to the action of rock-pressure and unfavourable to hydrostatic pressure transmitted from a long distance. The mouth of this Kynuna well is at the height of 655 feet above sea-level; its depth is 2221 feet; it has been bored through a variable series of shales, clays, sandstones, thin limestones, sand-rocks, etc.; though some of the beds of shale are thick and there is one 100-feet seam of sandstone, the section of the well shows no less than eighty-eight strata. The carbonized wood in the sandstones, and the plastic, chocolate-coloured and variegated clays indicate that the beds are partly of terrestrial and fresh-water origin. Water enters the well from twenty-two thin bands of sand and sandstone (see Fig. 7, p. 161); some of these bands are 4, 6, and 8 feet thick, and some are apparently only a foot or two in thickness. The nearest outcrop of the assumed intake beds is at Saxby Downs, 120 miles away, and it is improbable that the thin water-bearing sandstones should extend so far. Many of them doubtless thin out within a short distance, so that water could only reach them from the Blythesdale Braystone by passing through the interstratified

* H. C. Sorby, *Quart. Journ. Geol. Soc.*, vol. **64**, p. 214.

† For example, A. C. Lane, "The Chemical Evolution of the Ocean," *Journ. Geol. Chicago*, vol. **14**, pp. 221–225. 1906.

beds of clay; and even if the water could ooze through the clay, the frictional resistance would completely absorb all the water-pressure. Even if the sandstones were continuous to the outcrop, the water passing through them would lose much head by friction, and as in this case Saxby Downs is lower than Kynuna, the water would have had no head to lose.

This Kynuna well gives, moreover, direct evidence that its flow is due to a local cause. The first water reached rose 40 feet in the well; the second water rose 80 feet; the third 120 feet; the fourth 360 feet; the fifth 560 feet; and this steady increase in the height to which the water rose in the well continued till the 22nd contribution, from the depth of 2179 feet, rose 2246 feet, or to the height of 67 feet above the mouth of the well. The greater the depth of the water-bearing layer, *i.e.* the greater the pressure upon it from the overlying strata, the higher the water rises. The 2000 feet of strata pressing upon the thin beds of friable sandstone and sand squeeze out their water, just as clay in a mine is forced to flow into any tunnel cut through it.

It might be suggested that in such cases the deeper waters rise to a greater height because they entered the intake bed at a greater altitude. In the case of the Kynuna well we should have to assume that the water was taken in at many different intake beds, at such different levels that the water met with at the depth of 270 feet rises only 40 feet, whereas that from the depth of 1168 feet rises 560 feet, and the lowest water rises 2246 feet. The part of the Blythesdale Braystone area which might be supposed to feed this well may vary a few hundred feet in level; but there is no such variation in its surface as would be required to give such different pressures to these successive water-beds.

Moreover, according to the hydrostatic theory the intake bed which must supply the Kynuna wells is the northern outcrop of the Blythesdale Braystone or the Desert Sandstone overlying it. There can be no question in this case of the water coming from the Jurassic sandstones, as those rocks are not known outcropping in any position which can possibly collect rain water to feed the Kynuna wells.*

Mr. Cameron has given a section across this area and he represents the Blythesdale Braystone as one bed of very porous sandstone,† so that on the hydrostatic and hydraulic theories the water must percolate down through this bed of sandstone and then gradually spread through the thin layers of pre-cretaceous sandstone of the Kynuna well. This sheet of Blythesdale Braystone must act as a reservoir, which would equalize any difference in pressure from surface irregularities, and renders still more impossible of explanation why the water, if fed into the various sandstones of the Kynuna well from the Blythesdale Braystone, should be under such greatly different pressures.

The varying ascent of the Kynuna waters must have a local explanation, and the local rock pressure is quite adequate.

VIII. The Chemical Composition of the Well Waters.

On the water-pressure theory, as the water from the wells is derived from an eastern intake and is flowing westward, it would be expected that the water would become richer in dissolved materials on its passage to the west. As the

* The formation is not recorded in northern Queensland, although the discovery of *Thinnfeldia* in the beds marked as Desert Sandstone at Mount Mulligan on the Hopkinson Gold Field indicates their presence; in this position they are too far east to supply the flowing wells.

† Ann. Prog. Rep. of the Queensland Geol. Surv. for the year 1900, pl. ii.

Blythesdale Braystone is a rock of marine origin, the water percolating through it might be expected to show an increase in the amount of sodium chloride. As the Jurassic sandstone is, in part, at least, of terrestrial formation, the composition of its water might be more complex; but in either case a general increase in the mineral contents would be expected towards the west, since the water would have passed through more rock, and, owing to the increase of temperature with depth, would have greater solvent power. The chemical evidence, however, does not afford any convincing evidence in favour of the water-pressure theory. On the contrary, the chemical characters of the well waters are inconsistent with the simple westward movement of meteoric water. Thus, I showed in 1905, by a sketch-map of the salinities of the well waters, that crossing southern Queensland,* the eastern wells are richer in solid constituents than the central wells, and that the percentage of salts falls again toward the western margin of the basin. I referred also to the chemical analyses of a series of 13 wells on a line from east to west in New South Wales, and with the exception of the three last on the list, it is the second well in the series that is the most saline.

Mr. Pittman replies that the waters of 143 wells in Queensland are on the average less salt than those of the 14 in South Australia. Simple averages, however, are inadequate, for where the wells are shallow and the water is good, many wells are put down and the waters analyzed; where wells are deep and the water of inferior quality, fewer wells are bored. The best available data are the analyses of the Queensland wells, of which a long series is published in Mr. J. B. Henderson's tables of 1908.† From these tables the map (p. 232) has been prepared, showing the variations in chemical composition of the Queensland well waters. The waters from rivers, springs, and shallow wells, given in Henderson's list of analyses, are excluded; so also are most of those from the deep wells outside the flowing well area, though a few are included for comparison; and some wells are omitted, as the analyses are said to be unreliable or the results given are inadequate. Where waters of neighbouring wells have been analyzed the results are averaged. A list of the analyses used is given in an appendix, and the facts are graphically stated on the map (p. 232), which indicates the volume of total solids and proportions of the chief constituents. This map shows that some of the most saline waters come from shallow wells or from those east of the basin of flowing wells; or, as in the case of a well at Hughenden, actually from the supposed intake. The well at Dalby, an example of the waters found deep in the Jurassic sandstone near the eastern margin, is much richer in saline matters than water from the same beds which, on the water-pressure theory, has flowed through the rock for two or three hundred miles. At Winton the composition of two different waters is shown and the shallow water is by far the more saline, being specially rich in sodium and potassium chlorides. Comparison of the well waters in a series of lines across this map westward from the supposed intake beds shows that there is no regular increase of the saline constituents in the direction of the supposed flow. All the wells in one district may show a close resemblance, as in the south central part of the map; whereas in the central area, as around Longreach and Bradley creek, the wells show exceptional variety.

This map gives no evidence of any subterranean streams of water slowly

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* 'Dead Heart of Australia,' opp. p. 314.

† "Tables of Artesian Borings, Perennial Springs and Water Analyses," Queensland Water Supply Department, Brisbane, pp. 41–52. 1908.

working westward through a continuous permeable layer. It is true that the waters of the wells in variable strata vary in chemical composition; but such variations are usually easily explained. Some cases may be due to adsorption; but I am not aware of any artesian waters from widespread sheets of the same rock, such as the chalk of the London basin and the sandstone of Dakota, that show such striking changes in composition as the Queensland wells. Thus, according to Darton, the water in the great artesian basin of Dakota, which Mr. Pittman compares with the Australian wells, shows some slight variations in chemical composition. The water in Dakota has flowed underground for at least 150 miles and is more or less saline in all the wells; but, unlike the Australian waters, in only a few instances, says Darton,* are the dissolved constituents sufficient in amount to affect the taste or general usefulness of the waters, which can be used for irrigation throughout the basin. Indeed, Darton's map † shows that the gardens irrigated with this water are most crowded in Miner County, on the eastern border of the artesian area, although the water there has had a subterranean passage of at least 250 miles. Darton ‡ gives a list of 23 analyses from the South Dakota wells and a map showing the distribution of the variations in composition; and the list includes no such striking differences as those of the wells of Central Australia. The Dakota waters all contain sodium choride, and 11 out of the 23 contain sodium carbonate; but in no case does the sodium carbonate exceed the sodium chloride. All the wells contain some calcium carbonate and all but one sodium sulphate, of which the amount often exceeds the amount of chloride. The distribution in the total salinity is also generally regular. A well on the up stream side is the richest in salts, and the amount in a well to the west of Westport slightly exceeds that in the well to the east of that town; but the unusual salinity in these two wells is due to a great increase in the amount of sodium chloride, and can be easily explained, as Mr. Darton remarks, by some local variation in the rocks. The wells on the southern side of the basin along the course of the Missouri river are purer than those further to the north. Darton adequately explains this fact by the more rapid movement of the water through the especially porous sandstone near the southern margin, so that most of the salts there were leached out long ago; in the area to the north the underground water is flowing more slowly, so that the salts have not been removed so quickly. This case offers a striking contrast to the distribution of salinity in the Australian wells, in which the comparatively stagnant water in the central area is often the least saline, and wells on the line of the one admitted outlet are the saltest.

Reference to the chemical evidence renders it necessary to consider doubts thrown by Mr. Pittman on the reliability of the official analyses. He lays much stress on the fact that amongst a list of facts quoted as relating the Australian well waters to those of mineral springs is the recorded occurrence of 2·55 grains per gallon of zinc in a well at Toowoomba. This analysis (No. 86 of Henderson's Tables, 1908), according to Mr. Baillie Henderson, is one of those "made by the Queensland Government Analyst, Mr. J. Brownlie Henderson, and, during his absence in England, by his assistant, Mr. T. McCall." Mr. Pittman quotes a letter showing that the Government Analyst had been told, when the sample was sent to him, that the bore had a galvanized casing, in which the water had been

* N. H. Darton, 'Preliminary Report on Artesian Waters of a portion of the Dakotas,' 17th Ann. Rep. U. S. Geol. Surv. 1895–6, Part II., p. 677. 1896.

† *Ibid.*, pl. ciii.

‡ *Ibid.*, p. 677 and pl. ci.

standing; in spite of this warning, the presence of the zinc was recorded as one of the constituents. Some of the analyses in the tables are accompanied by the remark that owing to careless sampling or other cause, the analysis is unreliable. And in the absence of such warning in reference to the Toowoomba well, I naturally assumed that the one interesting fact stated about the sample was not due to casual pollution. The presence of zinc would not be proof of a plutonic origin, though it is a constituent of many mineral waters which are probably juvenile. It occurs, *e.g.*, in the waters of Elizabethquelle at Kreuznach, of Karlsbad and Levico.*

Mr. Pittman also denies, on the evidence of the Government Analyst, the presence of lithium in the well water from Helidon Spa; but the Queensland Government still continues to publish the occurrence of 2·68 grains to the gallon of lithium carbonate in that water, and last year the Helidon Spa water was still being sold with a label containing an analysis by Mr. W. A. Dixon, of Sydney, affirming the presence of the lithium, attached to each bottle. According to analyses by Mr. Brownlie Henderson (195 to 197 in the Queensland list), lithium is present in the springs at Herberton.

The chemical evidence to which Mr. Pittman devotes much attention I regarded as only of secondary value, for there is no chemical test applicable to these Australian well waters, which will certainly distinguish between a plutonic and a meteoric origin. I suggested that the analyses show that "much of the water is probably of plutonic origin" (p. 339), and on page 315 that the composition "suggests that much of it is derived from a plutonic source." But my argument from the chemical evidence as stated in the opening sentence of that section ('Dead Heart of Australia,' p. 312) was that "the chemical composition of the well waters does not afford any convincing evidence in favour of the artesian theory," and again (p. 339), "that the chemical composition of the well waters of Central Australia shows that there is no proof of any regular current in its subterranean waters from the north-east to the south-west." To that view I still adhere.

IX. Summary of Conclusions.

The theory that a large area of water under high hydraulic or hydrostatic pressure lay under East-Central Australia was, in the first place, assumed to explain the low discharge of the Darling; but the view that the volume of that river is reduced by great subterranean percolation is shown by Mr. Kenyon's letter to have been based on exaggerated estimates and may be dismissed as unnecessary. Secondly, it was claimed that the assumed percolation may be actually seen to happen where large rivers and streams cross the outcrop of the Blythesdale Braystone; but the maps of the Geological Survey of Queensland show that the streams which flow on to the Blythesdale Braystone drain insignificant collecting grounds, and suggest that this formation discharges more water in springs than it absorbs from the streams that flow on to it. Moreover, the Blythesdale Braystone has been found to have only scattered outcrops instead of the long continuous outcrop originally believed; and the view that the Jurassic (or Trias-Jura) sandstones are the intake beds is untenable for Queensland for the following reasons:—(1) the only outcrops of that formation which could supply the artesian wells are confined to south-eastern Queensland; (2) the rocks are drained by many

* A. Albu and C. Neuberg, 'Physiologie und Pathologie des Mineralstoffwechsels,' Berlin, 1906. P. 252, Table IV.; p. 251, Table III.

rivers which flow directly eastward to the Pacific; (3) that this formation is not heavily charged with water is shown by the evidence of the mines east of Toowoomba, and of the well at Dalby; and (4) the part of the artesian basin nearest to these sandstones is a low pressure area and cannot transmit high pressure to the areas farther away.

There is no evidence of any great percolation of water from the surface at the present day under the area of the flowing wells, for the assumed intake beds—the Blythesdale Braystones and the Jurassic (Trias-Jura) sandstones—are inadequate in area and have outcrops from which the water could escape at levels below the potentials of the wells.

The explanation that these wells maintain their flow in obedience to the principle that water finds its own level is contradicted by the irregularities in level to which their waters rise. This is shown by individual wells, such as those at Charleville and Kynuna, and in series of wells, such as those from Barcaldine and Longreach, in which sections show that the levels are irregular and the hydraulic gradient in places rises away from the assumed intake bed.

This feature of the wells, which is fatal to the water-pressure theories, is shown by the isopotential maps to occur in many parts of the area, as in the district of rising potential to the north of Lake Eyre. The essential accuracy of the isopotential maps has been confirmed by subsequent work.

Mr. Pittman's view that the water absorbed by the Jurassic sandstone near Toowoomba transmits a high pressure south-westward is opposed to the fact that in that direction is an area of low potential.

The theory that these wells are fed by modern rain water finding its own level does not explain the high temperature of the water from many of the wells, which is higher than that which I. C. Russell takes as clear evidence of a deep-seated origin. Neither does it explain the chemical distribution of the salts in these waters nor their periodic oscillation at non-lunar periods. The explanation that these periodic oscillations are analogous to periodic geysers has been reasserted by American authorities.

I accordingly hold that though water-pressure inevitably has some share in the ascent of the waters, the main factors are gas-pressure and rock-pressure. These are acknowledged as contributing factors in many areas of flowing wells; but in the great basin of East Central Australia they are the more important, and are to be regarded as the primary and not the secondary factors.

I therefore emphatically reaffirm the opinion that these wells are not maintained by an existing inflow of rain water and that this view was based on an erroneous analogy; and accordingly that the waste of water which was defended upon that view is deplorable and should be stopped as soon as possible.

There is, fortunately, no fear of the complete exhaustion of this water supply. After the wells have ceased to flow, their water can be obtained by pumping. The stoppage of the automatic discharge will lessen the waste of water, so that the decline of the water-level will become slower. Water, though in more limited quantity, could be raised to the surface artificially, but the greater the present waste, the sooner will it be necessary to incur the cost of pumping to obtain a supply.

APPENDIX I.

ANALYSES OF QUEENSLAND WELL WATERS USED IN FIG. 14.

GRAINS PER GALLON.

	No. of bores.	Total solids.	$CaCO_3$.	$MgCO_3$.	Na_2CO_3.	NaCl.	KCl.
Aberfoyle	1	21·18	1·14	—	7·3	10·82	
Adavale	1	88·7	0·7	0·2	63·59	21·78	—
Afton downs	5	30·7	2·8	4·2	7·0	7·6	—
Ambo	1	142·0	1·6	1·0	89·4	45·9	—
Aramac	1	21·8	2·6	—	10·1	6·1	—
Avondale	1	33·0	1·8	1·9	16·3	9·0	—
Bando	2	26·5	1·15	1·05	14·9	6·5	—
Barcaldine	2	65·1	—	—	65·1	—	—
Beaudesert	4	50·0	0·8	—	33·2	12·2	—
Beechal	2	27·7	2·0	0·2	17·0	5·3	—
Blackall	4	44·1	0·8	0·2	34·4	6·4	—
Boatman	1	34·1	0·89	trace	—	11·12	—
Bowen downs	4	41·3	say 8·0	—	—	9·0	—
Bradley creek	1	235·4	14·5	—	—	132·0	
Brighton downs	2	43·5	1·1	0·4	29·6	8·2	—
Brisbane racecourse ...	1	113·4	—	—		say 58·0	—
Brixton	1	83·5	1·04	trace		81·42	
Bunda Bunda	4	25·5	0·75	—	18·2	4·4	—
Burenda	5	21·5	0·7	0·6	8·5	7·4	—
Caiwarra	2	46·9	1·0	0·4	22·1	12·0	—
Cambridge downs ...	3	24·0	2·2	2·6	10·3	3·8	—
Camooweal	4	51·6	6·3	6·7	8·5	2·8	—
Charleville	2	64·3	0·6	—	37·4	20·9	—
Claverton	3	42·1	1·3	0·25	26·3	11·6	—
Cunnamulla	4	30·7	0·6	0·11	22·7	5·7	—
Dagworth	1	28·6	1·9	1·3	17·4	3·7	—
Dalby	2	120·7	0·5	0·2	66·0	51·0	—
Dalgonally	4	36·0	1·6	0·5	18·4	13.3	—
Darr River downs ...	1	53·0	1·6	trace	36·6	11·5	—
Dillalah	3	72·1	1·8	—	34·0 *	13·0 *	—
Eddington	5	25·3	0·5	0·25	16·5	5·1	—
Elverston	1	45·3	1·57	trace	23·3	13·9	—
Eulolo	2	25·5	1·5	—	17·4	3·7	—
Fort Constantine ...	3	57·3	1·1	—	41·4	13·0	—
Hamilton downs ...	1	26·9	3·8	1·7	9·1	7·7	—
Helidon spa	1	233·0	7·3	3·4	212·1	2·99	—
Hughenden Nos. 127, 175, 273	3	29·1	8·2	10·7	1·7	5·0	—
Hughenden No. 204 ...	1	281·6	45·7	6·86	65·24	51·94	
Kynuna	1	26·4	2·2	—	16·19	5·11	—
Laidley	1	622·3	—	—		say 9·0	—
Llanrheidol	1	30·0	2·5	trace	15·0	6·9	—
Longreach	1	80·8	0·9	—	61·4	13·8	—
Lucknow	1	32·0	1·2	trace	19·9	6·7	—
Manfred downs	8	26·6	1·5	—	16·0	7·8	—
Maria creek	1	864·5	15·2	45·45	576·0	223·85	—
McKinlay	1	42·1	1·18	—	26·5	7·86	—
Millungera	1	26·0	1·4	—	15·4	4·9	—
Morven	2	16·9	1·2	1·3	9·5	1·5	—
Mount Cornish, Dotswood	1	23·9	—	—	20·4	3·4	—

* One of these bores has the alkaline constituents calculated from the notes given with the incomplete analysis; the quantities given in that bore include a large amount of K_2CO_3 and KCl.

	No. of bores.	Total solids.	$CaCO_3$.	$MgCO_3$.	Na_2CO_3.	NaCl.	KCl.
Mount Morris	1	81·0	—	0·4	46·3	20·7	—
Muckadilla	1	32·8	3·3	1·5	15·9	6·9	—
Murweh	4	55·5	1·6	0·4	29·5	18·1	—
Normanton	2	275·7	—	—	160·0	115·9	—
Offham	1	41·0	1·4	1·0	29·2	7·2	—
Prairie	1	58·0	3·4	1·7	15·1	34·9	—
Quambeytook	1	25·6	3·24	1·4	10·6	7·75	—
Roma	4	51·8	0·9	0·5	29·0	13·0	—
Saxby	2	25·3	0·8	0·8	13·4	5·7	—
Sixty-five Mile	1	70·12	—	—	48·7	—	9·8
St. George	1	72·0	0·8	0·2	44·4	22·2	—
Tambo	1	40·6	—	—	—	—	—
Telemon	5	26·8	3·9	5·2	7·2	7·0	—
Thargomindah	1	56·0	—	—	46·8	9·2	—
Tinnenburra	8	35·1	0·7	—	21·2	8·9	—
Toolebuc	1	52·9	1·2	trace	36·0	14·2	—
Warbrecan	1	150·0	—	—	—	20·0	—
Warenda	5	46·0	0·3	—	28·2	10·7	—
Westland station ...	1	98·0	3·0	—	62·6	15·23	
Winton (deep)	1	25·0	2·7	trace	8·1	4·28	—
Winton (shallow) ...	1	219·8	9·43	—	—	196·2	
Woolerina	1	206·0	—	—	57·6	[28·0 17·0 Cl.]	—

RECENT PROGRESS IN GEODESY.*

By ARTHUR R. HINKS, M.A., Chief Assistant, Cambridge Observatory, and R.G.S. Lecturer in Surveying, Cambridge.

WITHIN the last few years geodesy has made remarkable progress in many directions. My object in bringing some of them before you this afternoon is twofold. In the first place, it may be useful to bring together some of the facts which are scattered up and down in the rather inaccessible literature of geodesy; in the second, I would invite discussion on the question whether an effort should be made to promote a gravity survey of Great Britain, of the latest pattern.

I. *Base Measurements.*—The whole art of base measurement was revolutionized by the discovery of Jäderin that long wires suspended under a constant tension in a horizontal catenary kept their length with remarkable accuracy, and by the subsequent use of the nickel-steel alloy "invar" in the manufacture of the wires or ribbons. The use of these wires is now almost universal—I believe that only the French geodesists have any serious doubts as to their value—and it is unnecessary to describe the ordinary manner of their use, other than by some photographs of the Spitsbergen and Semliki base measurements, which I owe to the kindness of Dr. Backlund and of Captain Jack, R.E. Experience seems to have shown that by the use of this apparatus we may gain the following important advantages:—

(*a*) Bases may be measured in places where it was formerly impossible to do so; in Scotland, for example, that country which General Roy described as "so very inaccessible by nature." A base was measured in Scotland last summer by the Ordnance Survey, which is, one may hope, the preliminary to a most interesting inquiry into the accuracy of the primary triangulation of this country.

* Research Department, April 27, 1911.

(*b*) Bases may be measured so rapidly that their number may be very much increased. The plans for the completion of the great African arc of meridian contemplate the measurement of at least one base per 200 miles. The Semliki base of 10¼ miles was measured in six weeks; and probably with the experience thus gained the trained party could have measured a number of subsequent bases in even less time. But the most remarkable instance of speed with which I am acquainted was the measure of the Russian base in Spitsbergen in 1901. Dr. Backlund left Pulkovo on June 11, stayed two days in Stockholm, reached Whales point on June 22, established a ground standard for the verification of the wires, measured a base of 12 km., and was back in Pulkovo on July 25. This base was measured on marshy ground, frozen below, which would have been quite impossible for bar measures (*vide* 'Mesure d'un arc de méridien au Spitzberg.' Mission Russe. Tome I., Section III. 1905).

(*c*) Bases may be measured uphill at each end. This was an excellent discovery of the Semliki base party. It immensely improves the chances of laying out suitable triangulation to connect the base with the main triangles; but it requires some modification of the standard pattern of levelling apparatus, which was not designed for going uphill. Perhaps, also, it may be desirable to make some experiments on the question whether the theoretical correction for slope of the catenary is strictly applicable; it would seem that the stiffness of the wire may somewhat modify the form of the curve.

(*d*) When necessary, the establishment of a base of verification, or ground standard, may be dispensed with. In the Uganda-Congo survey six wires were taken, three for the actual measurement, and three as reference wires for comparison with the former. The wires must be standardized before and after they go on service. In this connection the recent establishment of an admirable installation for standardizing wires at the National Physical Laboratory, Teddington, is of prime importance for British geodesy.

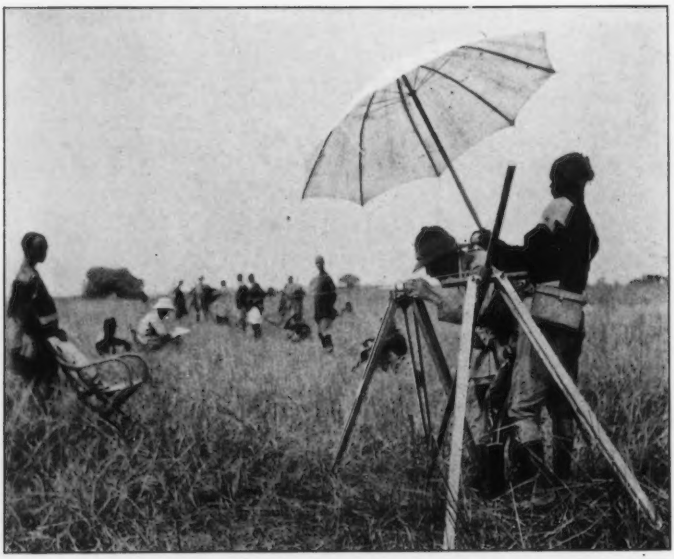
It seems to be within range of practicability to measure an arc of meridian directly with wires, and to dispense with triangulation. I hope that we may hear in discussion the views of those who have given special attention to such a project.

II. There are some other instrumental developments that deserve special notice.

(*e*) The determination of differences of longitude by wireless telegraphy is rapidly becoming possible. Successful results have been obtained by the Japanese navy, and interesting details are given by Mr. Nakano of the instrumental devices by which it is possible to record on a single chronograph either the feeble signals from a distant station or the violent waves from a high-power station close at hand. Determinations made in opposite directions showed that the "current-time" was very small (*Comptes Rendus*, Association Géodésique Internationale, p. 246. London and Cambridge, 1909).

(*f*) An interesting new instrument for the determination of time and latitude is the "astrolabe à prisme" of MM. Claude and Driencourt, which has been introduced into the French geodetic service, and used with success on the Congo-Cameroon boundary, and on the arc of meridian in Ecuador. The prism of 60° is fixed with refracting edge horizontal, and base next the object glass of a horizontal telescope. When the instrument is pointed in the azimuth of a star approaching 60° altitude two images of the star are seen, one by rays passing perpendicularly through the upper face of the prism and totally reflected by the lower into the telescope; the other by rays reflected from a mercury bath to the lower face of the prism, and thence from the upper into the objective. When the star reaches an altitude exactly equal to the angle of the prism the two images

DR. BACKLUND MEASURING THE SPITSBERGEN BASE.



TAKING READINGS ON THE WIRE, SEMLIKI BASE.

ADJUSTING THE STRAINING TRESTLE AND WIRE BEFORE READING.

coincide, and the time of coincidence is recorded. Three observations in suitable azimuths give time and latitude, by the method of Gauss.

As in all methods of this class, the preparation of a programme, and the reductions, are somewhat complicated. Nevertheless, those who have used the instrument speak of it with enthusiasm. A critical comparison of results obtained with the zenith telescope, the astrolabe, and the theodolite clamped at the altitude of the pole is much to be desired. It should be noted that the astrolabe is especially suited to work on the equator, where the last method fails (see 'L'Astrolabe à prisme': Claude et Driencourt. Paris, 1910).

(*g*) The construction of beacons is always a matter of great importance, and anything which assists in the rapid and accurate interchange of helio and theodolite is very desirable. The self-centering beacons used on the survey of Egypt consist of a brass casting with three radial V-grooves, mounted on a pillar of concrete. The feet of the theodolite or helio stand in the V-grooves, and it is impossible to erect the instrument in any but the correct centering.

III. Very remarkable progress has lately been made in gravity survey, and the investigation of irregularities of density within the Earth's crust.

(*h*) Colonel Lenox-Conyngham's pendulum work in India, 1903–1907, has frequently been referred to in the *Geographical Journal*. Its most striking result was the discovery of a "ditch" of deficient density, lying between the Himalayas and Burrard's parallel concealed chain of excessive density to the south ('The Pendulum Observations in India, 1903–1907.' Professional Papers, No. 10. Dehra Dun, 1908). Since then the pendulum work has been extended into Southern India, where the mountains are of extreme age. It is found that there the observed values of gravity are much more nearly in accord with the calculated values than they are in the comparatively recent Himalayas; the deviations of gravity from the normal which the presence of visible mountain masses would lead one to expect, are actually found to the extent of about 70 per cent. of this calculated value. The compensation by concealed deficiencies is, therefore, very incomplete; only 30 per cent., as against about 70 per cent. in Northern India (*Comptes Rendus*, Association Internationale Géodésique, 1909).

(*k*) The voyages made by Dr. Hecker, of the International Bureau, Potsdam, have already been noticed in the *Geographical Journal* (1909, Oct., p. 432). The value of gravity at sea was determined by comparison of the readings of the mercurial barometer and the boiling-point thermometer, and, in accordance with the acute prediction of Faye, the value was found to be generally normal over the deep oceans, the deficiency of density in the water being compensated by excess of density below the ocean bed. This very interesting result has been revised and confirmed by recent work on the effects of vibration of the ship, examined during a voyage in the Black sea on a warship placed at Dr. Hecker's disposal by the Russian Government; and the whole results have been recalculated as the result of the remark by Baron Eötvös, that the authors had forgotten to take into account the effect of the east-west component in the velocity of the ship, which would vary the rotational component of the force ('Zentralbureau der Internat. Erdmessung. Neue Folge der Veröffentl.,' Nr. 20 (Berlin, 1910).)

(*l*) The most complete study of the compensation of mountain masses, or isostasy, is that made by Mr. Hayford, of the U.S. Coast and Geodetic Survey, in three elaborate memoirs. The problem which Hayford set himself to solve was this: Mountains do not produce upon the direction of gravity the effect that their visible masses should produce; hence they must be compensated by invisible defects of density below. Within what depth below the surface is this

compensation completed ? With the differences between the geodetic and astronomical co-ordinates at more than three hundred stations as material, Hayford made five solutions of the equations of condition which represented the corrections to the assumed figure of the Earth required to reduce to zero the discordance at any station. The attraction of all visible masses within a radius of 4126 km. was taken into account ; and in a similar way the compensating "repulsion" was calculated on five assumptions :—

(1) That compensation is uniformly distributed over an infinite depth, or, in plainer language, that there is no compensation, the Earth being rigid and able to support the visible masses.

(2) That compensation is provided by a uniform deficiency of density to a depth of 162 km.

(3) Ditto, 121 km.

(4) Ditto, 114 km.

(5) Ditto, 0 km.

This last assumption would imply that the deviations of gravity had no connection with the visible masses.

Mr. Hayford makes solutions of the whole material on the five different assumptions, and finds the following values for the sum of the squares of the residuals on the five hypotheses :—

(1)	107,385
(2)	10,297
(3)	10,063
(4)	10,077
(5)	18,889

The evidence is decisive against assumption (1), and to a much smaller extent against (5). Between the others there is hardly anything to choose ; and it is clear that, *if the compensation takes the form of a uniformly distributed deficiency of density down to a certain limiting depth*, then the limiting depth is about 120 km. One must, however, admit that such an assumption is highly artificial. Mr. Hayford has made solutions on other assumptions, such as—

(6) Compensation decreasing uniformly with the depth, which gives limiting depth 189 km.

(7) Compensation confined to a stratum 16 km. thick, which gives probable depth of bottom 65 km.

(8) Compensation distributed according to "the law postulated by Chamberlin" (not stated), which gives limiting depth 310 km.

It does not appear, however, that Mr. Hayford has made any discussion of the very reasonable assumption that the depth of compensation is proportional to the height and weight of the visible mass—the "roots of the mountains" theory of the Rev. Osmond Fisher—and it seems probable that such a discussion would be well worth making.

The figure of the Earth derived from the final discussion is (published 1910)—

	Equat. rad.	1/Flattening.
U.S.C.G.S., 1910	6,378,388 m. ± 18 m. ...	297·0 ± 0·5
C.G.S.—Bessel, 1841 ...	+ 991 m. ...	− 2·2
Clarke, 1866 ...	+ 181 m. ...	+ 2·0
Clarke, 1880 ...	+ 139 m. ...	+ 3·5

(See 'The Figure of the Earth and Isostasy from Measurements in the United States, J. F. Hayford (Washington, 1909) ; and 'Supplementary Investigation in

1909 of the Figure of the Earth and Isostasy,' J. F. Hayford (Washington, 1910).)

(*m*) The comparison of astronomical and geodetic positions is a laborious and expensive way of investigating local deviations of gravity. But the remarkable application of the torsion balance which has been made by Baron Roland Eötvös has rendered possible a very detailed search for irregularities, and determination of their amount. The principle of the torsion balance is of course well known. The great achievement of Baron Eötvös is in turning a refined laboratory method into one that may be pursued with success in the field. The theory of the instrument can be put very precisely in mathematical language: it determines the second differentials of the gravitation potential at any station. With a balance beam only 22 cm. long, it is possible to determine the difference of the reciprocals of the maximum & minimum radii of curvature of the geoid at a point, and the direction of maximum curvature; the "gradients" of gravity at the place, and the direction of the steepest gradient. Baron Eötvös shows how to deduce from these observations, combined with a pair of geodetic-astronomical positions, complete information as to the deviations of gravity in a territory. A great advantage of this method is that it is possible to feel one's way, step by step, towards regions of disturbance, and to select a station for the morrow from the indications obtained in the observations of each day. "This voyage into the unknown, far from mountains and from all other irregularities in the distribution of masses, had a peculiar charm. As we marched on a perfectly level plain our instruments continually revealed to us something that was hidden below, and we could direct our steps always so as to follow or cross a series of masses, and so get to know them better and better" (*Comptes Rendus*, Association Internationale Géodésique, 1909, Annexes A, p. 319).

IV. Several large enterprises have been brought recently to a successful conclusion.

(*n*) The Russo-Swedish measure of an arc of meridian in Spitsbergen is a good example of successful work under unusual and difficult conditions. It supersedes the old arc of Lapland as the most northerly practicable arc, and is an invaluable contribution to any future discussion of the figure of the Earth.

(*o*) The Uganda-Congo section of the 30th meridian arc in Africa is small in itself, but of great importance as an incentive to Germany to undertake her share between Tanganyika and Uganda.

(*p*) In the near future we may expect the publication of the official account of the remeasurement of the celebrated "Arc of Peru," now in Ecuador, near Quito. This great piece of work was undertaken by the Paris *Académie des Sciences*, and entrusted to the *Service Géographique de l'Armée*, under the charge of Colonel Bourgeois. An excellent general account of the enterprise has been written by Capitaine Perrier, and published in the *Révue de Géographie*, Tome II.

V. In conclusion, I would invite discussion particularly on the question, whether it would be practicable to measure an arc of meridian in Great Britain directly with invar tape, without triangulation. Proposals to this effect have already been made, and the scheme put forward involved frequent determinations of latitude, which in our cloudy climate present some difficulty. I would ask, further, whether an effort should not rather be made to institute a survey of Great Britain with the torsion balance of Eötvös. The known deviations of the vertical in this country are considerable, and it seems to me that if an opportunity should arise, there could be no more useful and interesting addition to the geodesy of our country than a gravity survey with the Eötvös balance.

Discussion:

Sir DAVID GILL: The proposal to measure an arc of meridian directly by the use of invar wires does not seem to me to be desirable in a country like this, which is intersected by walls, cultivated fields, and all sorts of difficulties of that sort. The ordinary methods of triangulation, with a number of base-lines as frequent control, would afford all the accuracy of practical value to geodesy. I think, too, that the establishment of such very numerous latitude stations as at every few miles would be unnecessary, particularly in view of Eötvös' work. I venture to think that good latitudes determined at each trigonometrical point would be sufficient, but I certainly think every one of those points should be also studied by Eötvös' method of determining the local attractions. In that way we should have a knowledge at least of the true length of an arc of meridian in these latitudes incomparably superior to anything that has yet been done in geodesy. There are a number of very interesting points raised by Mr. Hinks, and in particular the question of the value of ground standards, as compared with transported standards. As to the use of wires, three in the field and three, as it were, at rest, this is very good, and in a small country like this, where you can transport to a central station all your wires for frequent comparison, it is all that is necessary. But there are surveys, in Uganda for instance, or if the African arc is further extended, and so on, where some kind of a standard not so difficult and troublesome as the transport of a bar would be of great advantage, and I have been trying to get nickel tape made. Pure nickel has great molecular stability. Unfortunately it has a much higher coefficient of expansion by heat than invar, but it has a very easily determinable electrical resistance, and it is quite easy to devise an electrical method for determining the electrical resistance of a stretched tape, so that the absolute length of the tape can be known in terms of its electrical resistance instead of its temperature. It would be undesirable and unnecessary to use such a tape in the measurement of the base, but only desirable to employ it as a means of comparing the instantaneous lengths of the invar tapes in use. Such a tape, I think, would be an invaluable standard for use in places where you are far removed from a standard observatory where tapes could be compared. That is a thing I am trying to get made in practical form, and it can be made in such practical and simple form that you can read off in fractions of a millimeter the instantaneous corrections applicable to the length of the tape on a dial without errors of a sensible amount. There are several improvements I think possible on the method of stretching the wire. I am having just now such stands made for Sydney in which you have screw methods of aligning and of elevation, so that you can bring the division lines on the tape (or on the scale of a wire) exactly to the plane of the reference mark and to alignment with it by a delicate screw-motion, instead of by the rather rougher process described by Mr. Hinks. I should like to have spoken upon the details of base measurement, but I am sorry to say I have not time, and I know there are many here who wish to speak on this interesting paper. I have never heard in my life so clear and concise an account of the present state of geodesy as that to which we have listened to-day, and I am sure we are most grateful to Mr. Hinks for bringing it before us in this neat and compact form.

Colonel C. F. CLOSE: I am sure we are all very much indebted to Mr. Hinks for having given us this account of what is going on. I have learned a great deal from it. It is a very good thing for us to deal with geodesy in this Society. Geodesy has not got a home anywhere else. It is very much allied to a great deal of the work we deal with, and it helps to stiffen up the work of the Society and make us more accurate. As to questions of detail: Mr. Hinks told us that

there was some doubt as to whether the calculations of a wire on a slope had been properly gone into. I believe Prof. Henrici and his son, Captain Henrici, are now dealing with that question. It is not in a satisfactory state yet.

As to Eötvös' method, it seems to me like magic, and I should like to ask if it has been rigorously tested against ordinary normal methods. The question of measuring a line in England along a meridian with invar wires was discussed at the British Association at York. Nothing came of it. I do not think any one took up the proposition very enthusiastically. It would be an interesting thing to do, but I imagine it would be rather expensive. A possible line would be from Southampton, through Oxford to Durham.

Mr. J. E. Sears: I think there is only one point in Mr. Hinks's paper on which I am competent to say anything. That is the point about the corrections for the slope. If that is being gone into, one of the points which needs attention is the fact that when you are measuring up a slope, the horizontal tension in the tape is not the same as the tension of the dead weight at the end. The tension on the slope is equal to the dead weight, and that makes quite a considerable difference. With the tape practically flat, that does not come in. Mr. Hinks has referred in very eulogistic terms to our plant as Bushy. This is one thing we have had in mind to do for some time, both experimentally as well as by calculation. I have not yet gone into it fully myself. I have been very interested and pleased to hear Mr. Hinks's paper.

Captain W. J. Johnston: I did not hear Mr. Hinks speak on the use of invar in the field, but I may perhaps give briefly my own experience whilst measuring a base in the north of Scotland two years ago. In the first place, we used tapes—not wires. There is certainly some doubt as to which is the best form. Personally, I prefer tapes. It is impossible not to detect twist in them, whereas with wires, unless every care is taken, a twist may occur and remain undetected. With tapes the wind is probably more troublesome, but it is easily observed when this is so, and the only thing to do is to cease work. As to the question of measuring on the slope, there is no serious difficulty, but when the slope becomes steep, say over 1 in 12, or even 1 in 15, great care must be taken that the proper correction is applied for the deformation of the catenary. The main point in the use of invar tapes is the simplicity in use, and the rapidity in progress, and this very naturally affects the cost. The chief uncertainty up to the present has been the temperature coefficients, and up till a recent date it has been assumed that all invar from the same ingot had the same dilatation constants. This is not the case, as was proved in the wires used on the Semliki base, and also on the tapes we used in Scotland. After all, are we not going a trifle too far in all the refinement made in standardization when we are certainly not able to be sure of how much of the air temperature the tapes are actually taking up during use? I think that with ordinary care and without any great refinement in standardization a base can now be measured to within a certainty of 1 in 500,000, and this is sufficiently good for any triangulation.

Mr. Reeves: When published in full, Mr. Hinks's paper will, I feel sure, be extremely useful for reference. In some respects it will occupy a unique position in the *Geographical Journal*, for, so far as I can remember, nothing of exactly the same character has appeared before. There are a good many things I should like to say about what we have heard, but there is hardly time now, so I will merely ask one or two questions. We have heard on several occasions lately that the main triangulation of the British Isles, although sufficiently accurate for all purposes of the Ordnance Survey maps, is not quite up to the high standard of modern geodesy and recent triangulation on the continent carried out with

modern instruments and improved methods. The other day I was looking at a table setting forth the relative merits and probable error of recent geodetic triangulation of European and other countries, and I think our own country stood about tenth on the list. Major E. H. Hills, in his address as president of the Geographical Section of the British Association at the Dublin meeting in 1908, dealt with this subject, suggesting that certain chains of triangulation should be remeasured, and it would be of interest to know exactly what it has been found possible to do in this matter.

Captain JOHNSTON: The idea is that certain lines in the existing triangulation should be checked before any bigger scheme is undertaken. A base has already been measured, and the extension from that to existing primary trigonometrical stations is being now carried out. It will then be necessary to recompute the geographical positions of these points from the new base, and if there are any outstanding differences, it will then be a question for consideration whether it is essential to remeasure the arcs of meridian and parallel. Personally, I do not think any appreciable differences will be found to exist. Continental geodesists have been inclined to disregard our contribution to European geodetic enterprise, and, I think, unjustly so. It should be remembered that our triangulation was the first in the field (and, as a matter of fact, it was the excellence of our methods which induced the French Government to remeasure their arc of meridian), and that the geodetic values of the stations are derived from a very large network of triangulation. Moreover, if we disregard certain stations in the lowlying Eastern Counties, where scaffolds were used on church towers, etc., we should very appreciably reduce the mean triangular error of the British Triangulation.

Mr. REEVES: I should also like to ask about the trans-continental arc across Africa. Of course, we all know of the excellent work carried out under the direction of Sir David Gill in South Africa, and the section lately completed in western Uganda; but what about the other sections of the long chain triangulation? What are the Germans doing with reference to the part through their territory? And then what progress has been made with the long stretch from the lakes down the Nile valley through Egypt. If Mr. Hinks, or any other gentleman present, can give us a little definite information on these points, I am sure we shall feel greatly obliged. Perhaps he will also state if there is really a probability of this important work being carried out in its entire length as originally proposed.

Colonel CLOSE: I will leave Mr. Hinks to answer that.

Mr. HINKS: It is rather a serious responsibility that Colonel Close has put upon me, but as I have no particular knowledge of the inner difficulties, I should say yes, the work will be finished. I think the driving power which is in Sir David Gill will have a great deal to do with that matter. I am greatly obliged to the various gentlemen who have spoken, and perhaps I may take one or two points. With regard to the question of multiplying the complication of base measurement, I should be, as far as I am able to judge, very much in sympathy with Captain Johnston, and rather against the idea that it is worth while to have elaborate screw adjustments on the straining tripods, and so on. I have tried these measurements with Dr. Guillaume's apparatus, and it seems to me in a very little while one could get a tripod sufficiently near the mark without wasting time upon complicated screw adjustments. With regard to Colonel Close's question, Has Eötvös' work been tested against normal methods? one can say, Yes. The bulk of the very long and elaborate communication that Eötvös made to the International Association in 1909 was concerned with the comparison

of his results with normal methods. In 1906, at Budapest he showed that he could get good results, which meant something. By the time he came to the Congress in London he was able to show conclusively that that something was really related to the ordinary work. The Hungarian Government has supported him, and he has been able to carry on good triangulation and good pendulum work entirely to check all this work of the torsion balance. With regard to what Captain Johnston was saying about the question of the determination of the constants of the wires or tapes, and especially with regard to the assumption that you can test the coefficient of expansion for an ingot, and that will give you the coefficient for each wire, I think in this matter we are much indebted to Mr. Sears, because I believe the National Physical Laboratory methods of testing the expansibility of each wire is an enormous advance upon Guillaume's work. At the same time I think, perhaps, it is a little bit unfair to condemn Guillaume's assumption too much on the strength of what happened with the Semliki wires, because there was in the manufacture of those wires a confusion. The manufacturer succeeded in mixing up two sets of wires. That unfortunate incident of course did a great deal to discredit the wires for the time being.

But from what Captain Johnston and Mr. Sears have said, it is evident that confusion between two ingots is not always responsible. Different coefficients of expansion have been found for wires which, according to Dr. Guillaume, have undoubtedly come from the same ingot. This appears, however, to be unusual, for Mr. Sears has told us that in many cases examined at Teddington wires from the same ingot really were homogeneous; and in cases where they have tested the two halves of a wire independently, no difference was found. I think Mr. Reeves's questions about the re-measurement of the British triangulation have been answered by the discussion which took place at the time. One is very glad the Ordnance Survey have taken up the matter. With regard to the question of the accuracy of Colonel Clarke's meridian arc of Great Britain, we are very glad to have elicited from Captain Johnston his opinion that it is not fair to burden that arc with the errors of the difficult triangles in the Eastern Counties, which do not in reality form part of the arc at all. It would be a valuable outcome of this discussion if Captain Johnston would get out the actual triangular error of the triangles which Clarke used, so that we could judge how far the supposed inferiority, according to Ferrero, of the British arc is really established.

I think I have already answered Mr. Reeves's question as to whether the work in Africa is going to be finished. I take it that the Germans will certainly do their share, though at present they are more sympathetic with gravity survey than they are with triangulation. I believe Dr. Helmert has got out estimates. They are working away energetically in Egypt under Mr. Keeling, getting up the Nile at a considerable rate, and I believe they have made a reconnaissance up into the Sudan. The sudd and the marshy ground are a difficulty, but I remember Captain Lyons saying that a preliminary reconnaissance suggested carrying the chain away from the river up there.

Prof. Myres: I think we shall all agree that this is one of the most instructive meetings the department has had this session, and we are indebted for this, in the first place, to the extremely lucid way in which Mr. Hinks has exhibited to us the outlines of a difficult matter, and also to Sir David Gill and the other members who have contributed to the discussion. If a mere amateur might venture a comment, it would be to note the extremely interesting way in which stimulus is given to new methods, and new discoveries of apparatus, from the practical necessities of work under unfamiliar and difficult conditions in all parts of the world—in tropical forests and the like—introducing new problems of a

practical kind, and suggesting fresh means of dealing with them. I hope that, as one outcome of the discussion to-day, there will be some official announcement of the magnitude of the error of our own triangulation in view of the statements which have become current as to the extent of this inaccuracy. I imagine there will be no very serious difficulty. Mr. Hinks suggested, as another practical outcome, that it might be possible to make experimental trial of the new invar wires or tapes in this country, and the suggestion was pressed home by another speaker that Mr. Hinks at Cambridge, in collaboration perhaps with the Oxford School, might find it possible to do something of that kind. I hope he will take Dr. Herbertson into conference, and see whether something could not be done. A practical demonstration in geodesy of this sort would do much to bring home to the student the exciting possibilities of what at first sight is unwisely believed to be a repellant part of geographical work, though it is one which Mr. Hinks has succeeded in making extremely attractive to us all on this occasion.

REVIEWS.

EUROPE.

English Local Geography.

'The Reigate Sheet of the 1-Inch Ordnance Survey: a Study in the Geography of the Surrey Hills.' By Ellen Smith. London: Adam & Charles Black. 1910. *Maps, Plates, and Illustrations* (*Maps in separate case*).

We heartily welcome a book of this description as making a commencement of that detailed local study of the geography of England which still remains to be taken up in schools. The authoress is intimately familiar with every acre, one might say, of the area of 216 square miles represented by the Reigate Ordnance Sheet, No. 286, and her clearly written book, issued under the auspices of the London School of Economics, does full justice to a region which for both scientific interest and picturesque beauty can scarcely be surpassed in England. The sharply defined geological and topographical zones of Surrey with the characteristic differences of vegetation to which they give rise, as also the interesting relation of the economic resources and industries, the lines of communication, the place-names, etc., of the country to these zones are discussed in a very thorough scientific manner.

On page 54 Miss Smith quotes the Act 27 Eliz. cap. 19, entitled "An Act for the preservation of tymber in the Wildes of the Counties of Sussex, Surrey, and Kent, and for the Amendment of the High Waies decaied by carriage to and fro Iron Mylles there." This, of course, relates to the old iron industry of the weald, and to the great oak forest of that area which at that time had to supply wood for the navy. This quaint old English clause suggests rather vividly to the imagination what the "wildes" of the three counties named were then really like, for to this day there are large areas in Kent, Sussex, and Surrey which present that wild, picturesque, tangled character seldom met with in the flatter, tamer, and more cultivated shires just north of the Thames. Miss Smith speaks truly concerning the surprisingly primitive character of the people who live in the deeply furrowed region around Leith hill, many of whom know not the luxury of a coal fire. The deep and tangled woodlands that stretch away from the pine and heath-clad slopes of Leith hill are extremely beautiful, and we know of few districts at the same short distance from London where there is so strikingly manifested that sweetest phase of

the flowering year, namely, the blooming of the wild hyacinths in the oak woods (and here even in the meadows) during the second and third weeks of May.

We cannot but deplore how continuously Surrey is being robbed of its rural charm by the penetration into the heart of the country of London's outer suburbs, even though a certain compensation may not be entirely wanting in the softened tones of culture which proximity to the great metropolis has thrown over a salubrious tract of country, once a singularly uncouth, wolf-ridden wilderness.

L. C. W. B.

'The Danube with Pen and Pencil.' By Captain Granville Baker. (London: Sonnenschein. 1911. Pp. xvi., 191. *Illustrations.* 16*s.*) This is a very pretty volume, in spite of an occasional descent to a level almost of caricature in the portrayal of men and women. Ample justice is done, both with the brush in colour and with pen and ink, in the illustration of the sites of inspiration to the artist which abound on the banks of the Danube. The text is a medley of narrative, description, and history. The style of a past generation would seem in certain particulars (such as the frequent personification of the rivers) to have inspired the author.

'Scrambles in Storm and Sunshine.' By E. Elliot Stock. (London: Ouseley. *N.d.* Pp. 210. *Illustrations.*) This is a book of mountain-climbers' adventures, more easily readable by the ordinary lover of mountains than others of its class, as it hardly touches the technicalities and extreme details of the sport. It deals with the Matterhorn, the Schreckhorn, the Mönch, and other famous Alpine peaks, and also with our own Lake District.

AFRICA.

Vegetation of Africa.

'Die Pflanzenwelt Afrikas insbesondere seiner tropischen Gebiete. Grundzüge der Pflanzenverbreitung in Afrika und die Charakterpflanzen Afrikas.' Von A. Engler. Band I. "Allgemeiner Überblick über die Pflanzenwelt Afrikas und ihre Existenzbedingungen.' *Maps and Illustrations.* Leipzig: Wilhelm Engelmann. 1910.

Slowly but surely the great and monumental work, 'Die Vegetation der Erde,' edited by A. Engler and O. Drude since 1896, is progressing. We have before us the two parts forming the first volume of a further monograph of the series, in which Engler has undertaken to describe the vegetation of Africa, and more particularly that part which lies in the tropics. This particular monograph will be complete in five volumes. The first volume contains (in over 1000 pages) an introductory review of the vegetation of Africa and the conditions by which the plants are surrounded. The next three volumes, one of which appeared in 1908 (*Journal*, vol. 33, p. 584), will be devoted to a systematic account of the African plants. The last volume will contain a detailed survey of the plant-formations of tropical Africa and their ecology. The first volume, now under review, is of the most direct interest and use to the readers of this *Journal*, but at the same time the very numerous plates and figures contained in the other volumes, and illustrating plant-formations and plant-species, are indispensable to any one who wishes to study thoroughly the vegetation of tropical Africa, be he geographer or botanist.

After giving a detailed list of the travels in and expeditions into Africa, from which botanically important results were obtained, the author, by way of introduction to the African flora, takes the reader on an imaginary journey

through the African continent, in the course of which he calls attention to the most characteristic features of the vegetation. Coming from the south of Spain, the traveller will not find any very striking differences in the flora of the northern coast of Africa where it is washed by the Mediterranean. Most of the plants of this portion are Mediterranean in character, and it is not till we get further down the west coast as far as Mogador that we meet with the first true African types, such as species of Euphorbia, *Acacia gummifera*, and *Argania sideroxylon*. The whole northern coast is mainly Mediterranean as far as Egypt, as is also the northern portion of the great African desert. But towards the centre of the Sahara the vegetation gradually changes, and with the appearance of *Acacia tortilis* and *Hyphæne thebaica*, we have before us again two typical and true African plants. In the same way the northern coast of Egypt and the northern Egyptian deserts are mainly Mediterranean; the Arabian desert, however, shows some true African types, and the Nubian desert is free of any Mediterranean influence. The author now takes the reader along the valley of the Nile to Abyssinia, down to the Red sea and its coast, through Somaliland to Socotra, and thence to British East Africa. The steppes on the plateau near Mount Kenia are then described. In rather more detail the vegetation of German East Africa is now put before the reader, from the coast to the steppes of the interior, and through numerous intermediate stages to the xerophil steppe forest, and finally to the rain forest on the hills. Little is known of the vegetation of Portuguese East Africa, and thus we are taken along the coast to Natal, but not before a sketch has been given of the plant-world and the changes it undergoes in passing from Beira through Umtali to Salisbury. We then pass through the Orange River Colony to the Kalahari desert and the Karroo, after which the south-western portion of the Cape, with its winter rains, is visited. Passing up the western coast the vegetation again changes on account of the rain period being also the warm period of the year. German West Africa is visited, and an excursion is made from Benguela into the interior of Angola. The lower valley of the Congo and its upper basin, the district between the great African lakes and that surrounding Mount Ruwenzori, are reviewed. The Kamerun, being German territory, is gone into in greater detail. The upper basin of the Nile is touched upon; our journey takes us across Africa to the Niger, Lake Chad, the coast of Guinea, and it ends in Senegambia, as far as the continent is concerned. But the Canaries and Madeira are included in the floral area to which tropical Africa belongs.

In a few short chapters the general morphology of the African continent is discussed, and an account is given of the meteorological and edaphic conditions, as far as they affect plant life, the former being illustrated by some good maps. An attempt is made in a further chapter to distinguish the regions and their characteristic vegetation as we pass from plain to plateau, but this is much complicated by the variation in the rainfall. Briefly, the typical African formations are enumerated, and the elements of the African flora are separated out in order to show the relation of the latter to that of other countries. Engler divides the African flora into four large areas. The Mediterranean area includes the whole coast from Morocco to Egypt and the northern portion of the Sahara and Arabian deserts. From this is separated the Northern, Afrieo-Indian, desert area, the area of the African forest and steppe land, and, lastly, that of the south-west portion of Cape Colony. The volume concludes with an account of the development of the African flora.

It is quite impossible, within the narrow limits of a review, to give any idea of the enormous amount of material of which use has been made in order to write

the book before us. Hardly a spot on the African continent remains untouched, and of almost every corner are we able to get some idea of the vegetation.

O. V. D.

Geology and Geography of Nigeria.

'Description Géologique des Regions situées entre le Niger et le Tchad.' By G. Garde. Paris: A. Hermann et Fils. 1911. 10 *fr.*

Our knowledge of the geography and geology of the Central Sudan has been rapidly amplified within the last decade. The work begun by Barth and Overweg in the middle of the nineteenth century and thereafter long abandoned, has of recent years been in great part completed by the researches of MM. Foureau, Gautier, and Chudeau in the French Sudan, of M. Hubert in Dahomey, of Captain Freydenberg in the Chad region, and of Dr. Falconer in Northern Nigeria. To M. Garde, who accompanied as geologist the Anglo-French boundary commission of 1907–8 (Mission Tilho), has fallen the part of making a careful and interesting study of the regions situated between the Niger and Lake Chad. His book is a record of minute and painstaking observation, carried out, to say the least, under somewhat more uncomfortable conditions than those under which similar work is done in more favoured lands.

M. Garde's suggestion of an Eocene age for the sandstones of Sokoto and the middle Niger has been already established by Dr. Falconer, and his relegation of the intrusive soda granites of Zinder and Munio to a pre-Cretaceous age is likewise in accordance with Dr. Falconer's results in Northern Nigeria. His suggestion, however, that the desiccation of the ancient watercourses of the Sudan is due to the erosion of the superficial carapace of ironstone and the consequent absorption of the rainfall by the underlying sandstones, is one of which it is difficult to approve. According to him, if the soil were less permeable, there is still sufficient rainfall in the Sudan to give rise to very considerable rivers. In view, however, of the well-established evidence of a recent arid period in the Sudan, subsequent to the formation of the dry watercourses, it is difficult to believe that such a simple cause as the partial removal of the surface ironstones can be responsible for such extensive climatic changes. There is, on the contrary, good reason to believe that the present *régime* represents a gradual return to more humid conditions after a period of regional desiccation.

Of Lake Chad, M. Garde has much that is of interest to relate. He believes, with Dr. Falconer, that the present lake is of comparatively recent origin, and in no sense a remnant of a Tertiary sea, but he refrains from expressing any opinion as to the actual origin of the lake itself. He suggests that the floor of the lake is entirely formed of æolian deposits, and that the clays and marls have been deposited only in the hollows between the ancient dunes. This view, however, is accepted neither by Captain Freydenberg nor by Dr. Falconer, and would appear to be based upon somewhat insufficient evidence. The work as a whole, however, is most suggestive and full of interest, and a valuable addition to our knowledge of the structure of the Central Sudan.

J. D. F.

'The Geology and Geography of Northern Nigeria.' By J. D. Falconer, M.A., D.Sc., F.R.S.E. *Plates and Map.* London: Macmillan. 1911. 10*s. net.*

In this volume Dr. Falconer records the theoretical results accruing from the work of the Mineral Survey of Northern Nigeria from its inception in 1904

to its termination in 1909. The book, which bears evidence of much careful preparation, is for the geologist, although the economic side of the subject is relegated to an appendix of seven pages, and the lay mind may find too great a mass of detail throughout—misproportions which, though important, by no means alter the fact that the work and the included map will prove of the greatest value to the student of West African geology.

The crystalline rocks are divided into two series: one of schists and gneisses derived from a sedimentary group of grits and phyllites by processes of regional metamorphism and of folding—a far-reaching hypothesis—and an older "hard" series of gneisses, so called from their greater power of resisting erosion.

The Cretaceous rocks of parts of the valleys of the Benue and its tributary the Gongola are well summarized. Unlike what has apparently taken place in Southern Nigeria, the close of the Cretaceous period was followed by a time of disturbance, upheaval, and subsequent erosion; so that the Eocene beds, which cover three or four large areas, are unconformable to the underlying rocks.

The geological story, disjointed like that of other parts of the West Coast, is brought to a close by the formation of later Tertiary deposits—here termed "drift,"—of continental and lacustrine formation, and by two periods of vulcanicity, respectively mid-Eocene and late Pliocene. Study of the drift leads Dr. Falconer to conclude that two cycles of erosion and of deposition can be recognized, from which he deduces corresponding periods of elevation and depression. To the latter period of elevation is ascribed the production of two systems of asymmetrical arches, from which the present drainage system dates, and which have already been described in the pages of this *Journal* (February, 1911).

Amongst the many excellent illustrations, those of the characteristic "Inselberge" type of hill and those of the "puys" of the eastern part of the Protectorate deserve special mention.

JOHN PARKINSON.

SOUTH AFRICAN ARCHÆOLOGY.

'The Prehistoric Period in South Africa.' By J. P. Johnson. London: Longmans. 1910. 10*s*.

Prehistory in Negro Africa, like prehistory elsewhere, is a term of only relative value. A few portions of Africa are still in the Stone Age, and some may be said to have only entered on history with the commencement of the twentieth century. In the absence of any discovered written records or inscriptions connected with the mysterious stone-built settlements of South-East Africa, Africa south of the Zambezi can only have entered into history with the arrival on its coast of the Portuguese navigators of the fifteenth to sixteenth centuries, unless we should ever discover any more contemporary written information connected with the traditional voyage of the Phœnicians round the southern extremity of Africa at the behest of Pharaoh Necho in about 600 B.C. In such researches of scientific value as those which have been made by Mr. J. P. Johnson, Dr. Shrubsall, and others, no evidence has yet been collected to prove the existence of man in Negro Africa (or for the matter of that, in any part of Africa) at periods so remote as those now associated with human existence in Europe and Asia. Africa is a vast museum which illustrates human culture at many different stages from almost the earliest to the latest, but it does not follow that any of these stages of culture need be contemporaneous with the same degrees of culture in other parts of the world. For instance, it may be 200,000 years or 300,000 years since man was Eolithic in South Britain

or in the valley of the Rhine, while negro tribes remained in the Eolithic stage down to 2000 and 1000 years ago, if, indeed, some of the Bushmen were not still Eolithic when the Dutch settled Cape Colony in the seventeenth century.

Mr. Johnson's work is of high interest. It deals first of all with the stone implements found in South Africa, more particularly in Northern Cape Colony and the Transvaal, but also as far north as the Central Zambezi. It then treats of the Zimbabwe ruins and the similar construction of Nanatali.

Amongst interesting points, Mr. Johnson brings out (perhaps unintentionally) the greater resemblance, especially in the stone axe-heads, between the stone implements of prehistoric South Africa and those of prehistoric India; a matter of some interest, if one is disposed to favour the theory that the negro type originated in India and spread thence across Arabia into tropical Africa. Nevertheless, there are the most interesting and remarkable parallels between the Bushman art so well illustrated in this book and the art of Palæolithic and Eolithic Europe. Amongst such is the comparison on p. 67 of the engravings of arrow-like objects at Bloemfontein and those on the walls of caves in France. The engravings of rhinoceroses by Bushmen or early Bantu are strikingly like the rare pictures of the woolly rhinoceros painted on the walls of Spanish caverns.

According to the author of this book, no true Neolithic implements have yet been found in the sub-continent of South Africa. Man, existing and recent, in this region seems to have passed abruptly from a Palæolithic or even Eolithic stage into that of the use of copper and iron, the changes, no doubt, being the result of abrupt invasions of the sub-continent by superior races, quite possibly by Hamitic negroids before the arrival of the more negro Bantu. The greater part of the stone implements described by the author are attributed to a culture identical with that of the Acheulic or Solutric eras in Europe, with, however, some important differences, the Solutric implements of Western Europe being much bigger than those of South Africa, while the rock drawings or engravings of Western Europe lack a common type of pictorial representation which is peculiar to South Africa, and is well illustrated in the book under review, that which is described as "pecking," where the outline of the animal is given by a series of pecks, indentations, notches incised on the rock surface (an interesting illustration is given of another form of picture making where the whole surface of the animal portrayed is scraped so as to stand out in light relief from the darker tint of the unscraped rock). According to the author, a number of the rock drawings are attributable to the Bantu and not to the Bushmen. Some of these Bantu drawings are quite recent, since they illustrate groups of horses. The Bushmen, however, are connected interestingly with the stone implements of the past by one or two comparisons between their rare stone tools of the present day and those which have been found of some antiquity.

The second half of the book deals with the Zimbabwe ruins, and the author states his belief that all these ruins are the work of a Bantu people that had attained a more advanced stage of culture than any of the surviving tribes. "The ornaments, weapons, and pottery found associated with the ruins are characteristically Bantu." ". . . Zimbabwe was the fortified kraal of the head chief." Yet the author admits that it is probable that these Bantu occupants of Zimbabwe and similar stone cities traded gold with the Arabs on the east coast, and may have been helped by the Arabs in their mining operations, while he has collected and repeated interesting traditions pointing obviously to the coming of Arabs as miners into the Northern Transvaal several centuries ago, it may be at a relatively remote period. He offers no

explanation of the extraordinary round tower or the soapstone birds of Zimbabwe, and a good many of his readers who have likewise considered this unsolved problem of Zimbabwe will still find themselves unable to believe that these and similar stone cities of South-East Africa could have been entirely originated by a negro race, Bantu or otherwise. There must have been some element of the Caucasian—Hamitic or Semitic—in their origination and elaboration, whether it came through pre-Islamic or post-Islamic Arabs from the east coast, or was due to some southward migration of Hamitic negroids from the direction of the Victoria Nyanza, such as may by mixture with the Bushman have given rise to the Hottentot tribes and the Hottentot language, Hamites that were afterwards followed, conquered, and assimilated by Bantu negroes.

H. H. JOHNSTON.

ANCIENT NUBIA.

'Eckley B. Coxe, Junior, Expedition to Nubia.' Vol. 1, 'Areika.' By D. Randall MacIver and C. Leonard Woolley; with a chapter on Meroïtic Inscriptions by F. Ll. Griffith. Oxford: 1909. Vol. 2, 'Churches in Lower Nubia.' By Geoffrey S. Mileham. Vols. 3 and 4, 'Karanòg, the Romano-Nubian Cemetery.' By C. Leonard Woolley and D. Randall MacIver. Philadelphia: University Museum. 1910.

Whilst the Archæological Survey of Nubia has been concerned with excavations north of Korosko, the excavations recorded in these liberally illustrated volumes were on the portion of the Nile between Korosko and Halfa. This exploration was planned and financed by Mr. Eckley B. Coxe, junior, of Philadelphia, U.S.A., on behalf of the University of Pennsylvania, where most of the objects found have been deposited. The excavations were carried out by Mr. D. Randall MacIver and Mr. C. Leonard Woolley, in 1907, 1908, and 1909. The Areika and Karanòg volumes deal with cemeteries of the period of the Roman domination in Egypt before Christianity was adopted by the Nubians, and throw much new light on the history of this borderland of Ethiopia. The explorers maintain that we are here concerned with an outlying province of the Meroïtic empire, or perhaps a semi-independent buffer state between that empire and Roman Egypt. The cemetery at Anibeh, which they designate "Karanòg" because it seems to be the burial-place of that fortress town, they contend to be the work of the turbulent Blemyes, who were such a thorn in the side of Roman Egypt. There is a very interesting chapter on these Blemyes, with textual extracts from classical writers. Numerous Meroïtic funerary inscriptions were found, and Mr. F. Ll. Griffith makes a step towards their decipherment. His studies should be compared with those of Prof. Sayce. The separation of the words by dots (:) suggests a connection with Gheez or Ethiopic; the language cannot have a Nubian or Negro origin. Much of the art work, including the great variety of glass beads found and numerous specimens of pottery, is attributed to local culture. The painted wares, hand made and baked in an open fire, show characteristic differences from those made in Egypt. Volume 3 is a careful study, with maps and illustrations, by Mr. Geoffrey S. Mileham, an English architect, of the early Christian buildings between Faras and Halfa, a subject which has not hitherto received the attention it deserves. The early spread of Christianity in Nubia and the Sudan forms an interesting chapter in history. There is in these volumes much of a speculative character, the interest of which is mainly archæological. That so much of the arts and civilization can be attributed to the Blemyes will perhaps not be accepted without controversy, and is not supported by what we

know of the modern Beja. That the fortress town of Karanòg may be identified with the Chiris of Olympiodorus is very plausible; two other towns mentioned —Phoinikon and Thapis—are suggested to be Begrash and Taphis (the modern Tâfa). Mr. Mileham also locates some place-names mentioned by the Arab author Abu Selah. These volumes will be followed by others, for the excavations are to be continued for a period of five years in all.

F. A. Edwards.

AMERICA.

Patagonia.

'Viajes de Esploracion i Estudio en la Patagonia Occidental, 1892-1902.' Por el Dr. Hans Steffen, Profesor del Instituto Pedagójico, etc. Santiago de Chile: Imprenta Cervantes. 1909.

Dr. Steffen's work in the southern territory of Chile is well known, and he was chosen on account of his knowledge of the country as a technical assessor at the tribunal of arbitration in London for the determination of the Chilean and Argentine boundary. This collection of his narratives has been made at the instance of the Chilean Council of Public Instruction, which considered that it would be useful to teachers of geography. The narratives of the earlier journeys have been already published in the *Anales de la Universidad*, but those in the second volume have hitherto only appeared in summaries. Such are the explorations (among others) of the rivers Aisen-Mañiualcs and Cisnes, of the river Baker and Lake Cochrane.

The exploration of the country is still incomplete, several minor rivers and transversal valleys being unexplored, and, in particular, there are two large areas where the configuration has not been thoroughly studied. These lie along the meridional axis, one running northwards from the Baker inlet to about the parallel of 46°, and the other to the south of the same inlet as far as 51° 30′ approximately. The scientific investigation of the country is still more defective, in spite of the valuable work of several travellers whose names are recorded by Dr. Steffen.

AUSTRALASIA AND PACIFIC ISLANDS.

'The Island of Stone Money: Uap of the Carolines.' By Dr. William Henry Furness. (Philadelphia and London: Lippincott. 1910. 15*s. net.*) This pleasantly written book contains a good deal of interesting information, much of which will be valuable to the anthropologist because it is new or has not yet been presented in a ready and accessible form. But in spite of the excellent photographs, the volume cannot be regarded as a serious anthropological study, with the result that the reader is left hoping that Dr. Furness will before long see fit to give a more complete account of the polity of these interesting and little-known islanders. The book concludes with a sketch of the Uap grammar and Uap-English and English-Uap vocabularies.

C. G. S.

POLAR REGIONS.

'Les Expéditions Polaires depuis 1800.' By J. Denucé. (Antwerp: Van Hille-De Backer. 1911. Pp. 160.) This is a classified list of expeditions to the Antarctic and the Arctic, divided according to countries of origin, and giving the dates and names of vessels and chief officers and others connected with each expedition. The record is carried back (where necessary) to about the beginning of the nineteenth century.

MATHEMATICAL AND PHYSICAL GEOGRAPHY.

Aerial Surveys.

'Die technischen und Wirtschaftlichen Chancen einer Ausgedehnten Kolonial-Vermessung.' Auszug aus den Vortrag von Hauptmann Scheimpflug . . . Frankfurt a.M. (Sonderabdruck aus No. 11 der Ila-Wochen-Rundschau.) N.P., N.D.

'Der Photoperspektograph und Seine Anwendung.' Von Theodor Scheimpflug. (Separatabdruck aus *Photographischen Korrespondenz*, November, 1906.)

The recent development of dirigibles and flying machines has brought into prominence the question of making photographic surveys—a question to which considerable attention was given some years ago in days when the only means for lifting the observer or camera into the air was the ordinary balloon or possibly the kite. In general, the method then proved a failure, chiefly on account of the difficulty of identifying points on the photographs as seen from different angles. Thus, while it is often possible to get good results from exceptionally clear photographs of a country where the features are exceptionally well marked, the ordinary photograph of ordinary country is hardly capable of translation into a map. This difficulty still exists, and it remains to be seen whether improvements in photographic technique made in the last twenty years will suffice to overcome it.

The geometrical problem of converting a view taken at any angle of inclination to the vertical into a projection on to a horizontal plane or map is a simple one, and can be solved in a variety of ways. The apparatus of Captain Scheimpflug provides a battery of eight cameras, the centre one having its sensitive plate lying horizontally, and the other seven being disposed round the centre inclined at angles of about 30° to the vertical. In this way a single exposure takes in a wide angle of country, and photographs from three points at unknown heights, combined with the known position of two points on the Earth's surface, equivalent to the base-line of ordinary surveying, give all the data for computing or constructing the horizontal co-ordinates and heights above the datum plane of any point which can be identified on the three photographs.

The inventor has also designed an ingenious "photoperspectograph," an apparatus for rephotographing a view taken at any angle and projecting it into a horizontal or any other selected plane. This, however, is of limited use in map-making, as it is only applicable when the ground is perfectly flat.

Detailed proposals have been made for carrying out a survey by these methods of a large area, such as German South-West Africa, where the value of the country is too small to justify the cost of ordinary surveys. While fully recognizing the possibility of such an enterprise, we must confess ourselves sceptical as to its practical expediency. Unless controlled by a network of triangulation covering the whole area, the errors of a photographic survey would be cumulative, and probably in the case of photographs taken in mid-air would reach large magnitudes. If, however, a triangulation has to be made, the country must be traversed, and it would almost certainly be cheaper and more rapid, as well as substantially more accurate, to carry out a plane-table survey on the scale required.

The estimate by Captain Scheimpflug of the cost of a plane-table survey, amounting to no less than a minimum figure of £31 per square mile for a map on a scale of 1:25,000, is, by the way, enormously greater than we should contemplate as possible.

While not particularly hopeful as to the future utility of aerial surveys, we must recognize that the converse problem—the preparation of maps for the use of aeroplanists and pilots of dirigibles—is of great practical importance. This is a question to which much attention has already been given on the continent, though, as far as we are aware, it has not been discussed in this country. Very rapid identification of points is of course the main consideration, and we cannot help thinking that the ideal map would bear a close resemblance to a photograph of the country, coloured as far as possible in natural colours; possibly two sets of maps might be desirable, one for winter and the other for summer use. Conventional signs should be almost entirely excluded, though it would be doubtless necessary to generalize the representations of houses, bridges, etc. In this direction the study of photographs taken in the air cannot fail to prove profitable. E. H. H.

GENERAL.

Sir Francis Drake.

'The Family and Heirs of Sir Francis Drake.' By Lady Elliot-Drake. 2 vols. London: Smith, Elder. 1911. 31*s.* 6*d. net.*

Lady Elliot-Drake's history of the family and heirs of Sir Francis Drake is a very interesting work, well written, and entailing much judicious use of material; but the only part which we are justified in dwelling upon as geographers is that which refers to the great discoverer himself in the first 127 pages of the first volume. There are several points of interest in Lady Drake's notice of Sir Francis, and she is specially to be commended for inserting the whole of the important letter from Don Francisco de Zarate to the Viceroy of Mexico, which was discovered by Señor Peralta at Seville (not Simancas). It disposes, to a great extent, of the accusations of piracy. Drake's true place is that of a discoverer, not of a marauder. The speech of Mr. Julian Corbett, at our Elizabethan Commemoration in 1903, taught us never to forget that it was Drake who discovered the cape, since miscalled Cape Horn, and established the continuity of the Atlantic and Pacific oceans.

Most interesting to all must be Lady Drake's allusions to the relics of Sir Francis at Buckland Abbey, which was acquired by the great navigator himself, and Nutwell Court, which came to the family in 1731 through a marriage with the heiress of the great Whig lawyer Pollexfen. We hear of the miniature by Isaac Oliver in an oval enamelled locket with two pear-shaped pearl drops, the only portrait before the circumnavigation. Oliver must have been very young when he painted it. We hear also of the great Drake jewel presented by the Queen; of the silver goblets; of the silver flags with which the *Golden Hind* was dressed on the occasion of Queen Elizabeth's visit, now at Nutwell; of the Bible that went round the world; of the chair made from the timber of the *Golden Hind*, also at Nutwell; of the plot of the world, with Drake's track, engraved on silver by Michael Mercator in Holland; and of the famous drum on which the great Englishman's last salute was beaten as he was committed to the sea.

The Home of the Sea Otter.

'In Forbidden Seas.' By H. J. Snow, F.R.G.S. London: E. Arnold. 1910. 12*s.* 6*d. net.*

This account of more than twenty years' adventure in the waters of the North-Western Pacific in the pursuit of the sea otter is decidedly interesting. At one time the range of this valuable animal extended along the coast from

Yezo (Hokkaido), Japan, to the south of San Francisco, and it was found on the shores of the Kurile and Aleutian islands, Alaska, British Columbia, and California; but its numbers have been reduced almost to extinction, and on the American coast it is not now to be found south of Alaska.

Though not divided into two parts, the book may be so regarded, for the early chapters deal with the haunts, habits, and methods of hunting the sea otter, and the latter parts consist of reminiscences of personal adventure and experiences in its pursuit.

In his 'Notes on the Kuril Islands,' the author has already treated of the physical features, the fauna, flora, etc., of this volcanic region; but in the first chapter of this work he gives a brief description of the Kuriles, which, as he says, are in a region "so little known and frequented" that most people have "little or no idea where they are situated." The account ranges over many years, for as early as 1874 the author was shipwrecked on the island of Yetorup. There is an interesting account and history of the Kurilsky Ainu, who are thus described: "To-day the Ainu are the most docile, submissive, and spiritless people on the face of the earth," and it is stated that "their final extinction is all but certain." The peculiar pit-dwelling (*yurt*), half underground, of the northern Kurilsky Ainu is constructed of driftwood and covered with earth.

The method of hunting the sea otter as practised from a schooner fitted out for the special purpose is fully explained only in the works of the author. He describes it as "one of the most exciting and fascinating of pursuits," and his narrative is most interesting. Fore-and-aft schooners of forty to a hundred tons are used for the purpose, several hunting-boats being carried.

On page 69 the author says: "On this trip (in 1873) I witnessed an instance of what has often been denied, and that is an Ainu woman suckling a young bear. . . . I had often heard of this being done, but this was the only time I ever saw it."

There are several descriptions of volcanic eruptions and submarine disturbances, for the vessel sometimes passed close to them. Many storms and fogs were encountered, and there are tales of marvellous runs before the wind and weathering of storms. To show the precarious nature of sea-otter hunting, a list is given of between thirty and forty vessels lost, together with nearly three hundred lives, during the period over which the narrative extends.

A number of illustrations helps one to understand the methods and risks of sea-otter hunting in "forbidden seas."

W. B.

'Introduzione al Codice Leicester di Leonardo da Vinci.' By Gerolami Calvi. (Milan: L. F. Cogliati. 1909.) This is a preface to a facsimile reproduction of the manuscript of Leonardo da Vinci's treatise, 'On Water' preserved at Holkham. The author enters into an elaborate discussion of its probable date and finally assigns it to A.D. 1504–06. It may be noted that the St. Gervais mentioned and sketched by Leonardo was not St. Gervais-les-Bains in Savoy, as here suggested (p. ix.), but the suburb of St. Gervais on the right bank of the Rhône, which is incorporated in modern Geneva.

THE MONTHLY RECORD.

EUROPE.

Plains, Hills, and Mountains in Italy.—A recent publication of the Italian Ministry of Agriculture, summarized in the *Rivista Geografica Italiana* for March of this year, gives the results of a calculation of the areas of the kingdom and its provinces under the three categories of plains, hill country, and mountains. Although the basis of division between these does not appear to be precisely defined, and the absolutely valueless areas, forming about 8 per cent. of the whole, are left out of consideration, the general facts brought out are of some interest. Thus Piedmont is seen to be almost equally divided between mountains on the one hand and plains and hills taken together on the other. Liguria is occupied to the extent of 93 per cent. of its surface by mountains (the remainder being classed as hills), while Calabria, the Abruzzi and Molise, and Basilicata come out with 70 per cent. and upwards in the same category. On the other hand, almost half of the area of Emilia appears as plains, which also occupy 46 per cent. of the surface in both Lombardy and Venice. Apulia and Sardinia show the highest proportion of hills (71 and 67 per cent. respectively). Dividing the kingdom into northern, central, and southern, it is found that, in the first division, plains and mountains occupy 39 per cent. each, leaving 22 per cent. only as hills; in the second, hills and mountains are about equal, with 48 and 46 per cent. respectively, leaving only 6 per cent. as plains; in the third, hills predominate, reaching a percentage of 59, plains and mountains coming out as 16 and 25 per cent. respectively. Taking Italy as a whole, the division between the three categories is approximately one-fifth plains, two-fifths each hills and mountains. The small relative extent of level ground is worthy of notice in considering the productivity of the soil, the means of communication, and so forth.

The Winter Ice of Bavarian Lakes.—The twenty-sixth number (1911) of the *Münchener Geographische Studien* is a monograph by Dr. Hans Herpich upon the ice conditions of the South Bavarian lakes. There are several plates of curves showing the various relations connected with the subject, such as times of freezing and thawing of the various lakes, the duration of the ice cover, etc. The three primary factors affecting the ice-conditions are the depth of the water, the progress of the air temperature, and the occurrence of Föhn winds. With regard to the depth of the water, Dr. Herpich explains, of course, that the entire mass of water from top to bottom must be cooled down to the point of maximum density, 39° Fahr. (4° C.), before the freezing of the superficial layers can commence, this being the reason why deep lakes take longer to freeze than shallow ones. The influence of the temperature of the air is obviously of paramount importance, whilst the Föhn wind is capable of thawing in a few hours a thickness of ice which has taken as many months to form. Other factors affecting the processes of freezing and thawing are cloudiness, precipitation, wind, horizontal shape of the lake basin, and inflow towards the lake. The dependence of the freezing process upon cloudiness is best stated according to the propositions of Cholnoky in connection with the ice of Lake Balaton, in Hungary: (1) Ist die Strahlung am Eise mit Wärmelust verbunden (Ausstrahlung mehr als Einstrahlung), so ist das Anwachsen des Eises bei klarem Wetter intensiver als bei trübem; (2) Ist die Strahlung am Eise mit Wärmegewinn verbunden (Einstrahlung mehr als Ausstrahlung), so ist das Zerstörungswerk am Eise bei klarem Wetter intensiver als bei trübem. These two propositions, it seems to us, are self-evident, and

scarcely need to be brought into special prominence. When we want the ice on our ponds in the depth of winter to strengthen rapidly we invariably welcome a clear sky, knowing full well that the outgoing radiation during the twenty-four hours will far exceed the incoming radiation, when the days are so very short and the sun so low. In England the breath of the Atlantic may liquefy the surface of our lakes and ponds in the course of a few hours, but such a change can never be effected by—

> "the idle gleam that December's beam
> Can dart on ice and snow."

ASIA.

Kinthup's Explorations in the Region of the Lower Sanpo, 1880–1884.—Recent events, which have turned attention to the still unexplored section of the Brahmaputra intervening between the known portion of the Sanpo of Tibet and the plains of India, render particularly opportune the republication by the Survey of India of the narrative of the native explorer Kinthup (generally designated at the time by the terminal letters, K—P, of his name), whose part in extending our knowledge of the Tibetan river some thirty years ago runs some risk of being forgotten. The adventures of this persevering agent of the Survey Department were described, and illustrated by a map, in a report issued at Dehra Dun in 1889, and summarized in our *Proceedings* for the same year (p. 568); but it is not always remembered that the question of the identity of the Sanpo with the Dihong branch of the Brahmaputra was practically solved by Kinthup, to whom also we owe the first definite account of the falls by which the Sanpo is broken during its passage through the Himalayas, a little below the sharp bend made by the river on approaching the mountains. It must, however, be remembered that the traveller was not one of the trained explorers of the Department, but, after accompanying two of these on their respective journeys, went in 1880 merely as servant or companion of the Tibetan lama to whom Captain Harman entrusted the task of throwing marked logs into the Sanpo, in the hope of thus settling once for all the question of its identity with the Dihong. This lama proved faithless, but his companion made the most plucky attempts to carry out the allotted task. He eventually reached Onlet, a little above Miri Padam, which last, *so far as he could ascertain*, was only about 35 miles from the British frontier. His account of his journeys was given from memory two years after his return, and in the absence of any means of determining his position, was naturally too vague to admit of the accurate fixing of his terminal point, or to supply a trustworthy map of the districts traversed; though, as the only available source of information on many of them, it still has its value. Regarding the falls of the Sanpo, the narrative merely states that "the Tsangpo is 2 chains distant from the monastery" (at Pema Koichung), "and about 2 miles off it falls over a cliff called Sinji Chogyal, from a height of about 150 feet. There is a big lake at the foot of the falls, where rainbows are always observable." It may be remarked that the accounts given to Colonel Waddell (see his paper in *Journal*, vol. 5, p. 258, with reproduction of a native drawing of the falls) placed the height at about 70 feet only, and in either case the heights given do little to account for the enormous difference of level supposed to exist between the Sanpo and the plains of Assam.

Siamese Mountain Flora.—The first number of the *Kew Bulletin* for 1911 contains an article by Mr. A. F. G. Kerr on the Vegetation of Chiengmai, the chief town of Northern Siam, situated about 1000 feet above sea-level on the banks of

the Meh Ping. About 2 miles to the north-west is the foot of Mount Doi Sutep (5500 feet), with whose vegetation Mr. Kerr mainly deals. The mountain is composed of metamorphic rock overlain in most places by red clay. Around its foot the ricefields surrounding Chiengmai give place to a fringe of scrub jungle consisting of small thorny bamboo, bushes of *Capparis tenera* and *Zizyphus jujuba*, with scattered trees of *Acacia catechu*, etc. After passing through this scrub jungle one comes to a mixed jungle of medium-sized trees, partly deciduous and partly evergreen, the teak figuring among the chief species. There is an abundant undergrowth of herbaceous plants and shrubs, and there are several woody climbers. This jungle extends to the foot of the first steep slope, where it gives place to the deciduous jungle known in the country as "pah paa," and in Burma as "Eng jungle." The characteristic trees of the pah paa zone, which reaches to a height of about 2000 feet, belong to the *Dipterocarpaceæ*. This jungle is open, the ground being either bare and stony or covered with a tufty growth of grass; the trees are much infested by such parasites as *Loranthus* and *Viscum*. Above 2000 feet an oak jungle, containing several species of *Quercus*, succeeds the pah paa. In this zone epiphytic ferns and orchids abound. Between 3000 and 4500 feet the open valleys and moderate slopes are clothed with an evergreen jungle, recalling an English wood in summer, with *Quercus Junghuhnii* corresponding somewhat in appearance to our *Quercus robur*, and *Hypopitys lanuginosa* to our *Hypopitys multiflora*. The nut of this Siamese oak, called "Mahan Dohey," is esteemed good eating by the natives. Towards the summit of the mountain an open grassy jungle prevails on the slopes, whilst the lowered temperature is reflected in the appearance along the crests of ridges of a conifer, *Pinus Khasya*, as the predominant tree. At or near the top of the mountain, where the ground is level enough for humus to collect, is found the most luxuriant vegetation to be seen on the whole of Doi Sutep, all available space supporting plant-life. The white-flowered *Rhododendron veitchianum* is here a common epiphytic shrub, and many of the trees of *Pyrenaria camelliæflora*, etc., are heavily burthened with the orchid *Otochilus alba*. At Chiengmai the mean temperature of the air from April, 1909, to March, 1910, ranged from 87° Fahr. in April to 72° Fahr. in December. The rainfall during the same period was 58 inches.

AFRICA.

The Rhodesian Boundary with the Belgian Congo.—Arrangements have just been completed for the departure for South Africa of a party charged with the survey and demarcation of this boundary in accordance with the international agreement by which the divide between the basins of the Congo and Zambezi was accepted as the frontier. On the British side the work will be in charge of Captain L. W. D. Everett, who has passed through a course of instruction under Mr. Reeves, and has already had some experience of survey work in Somaliland.

The Duke of Mecklenburg's Expedition.—In consequence of the recent political events in Wadai, the programme of this expedition (see *Journal*, vol. 36, p. 220; vol. 37, p. 317) has been unavoidably curtailed to some extent. It was necessary to abandon the idea of proceeding east through Dar Kuti and the southern borders Darfur to the Bahr-el-Ghazal, and the Duke therefore devoted himself (with a portion of his staff) to work in the Bagirmi and Lake Chad region, while Lieut. von Wiese and Dr. Schubotz were commissioned to proceed to the Ubangi and make their way east to the Nile through the sultanates of the Niam-Niam country. They started by steamer for this purpose on January 1 last. Meanwhile the Duke carried out an interesting trip across the Logone

to the Musgum or Musgu country lying west of the Shari, the people of which he found to be of extraordinary interest. He afterwards proceeded to Lake Chad, of which an examination was made as far as circumstances permitted. The Duke is understood to be on his way home, being expected to arrive in Germany during August.

Research Expedition in Central Africa.—We understand that Mr. Egon F. Kirschstein—a Russian by birth though living in Berlin—who accompanied the Duke of Mecklenburg on his journey across Africa in 1907–08, and did good work there by his investigation of the Virunga volcanoes, is about to undertake a new expedition to Central Africa, this time on his own account. His route will be through Portuguese East Africa to Lake Nyasa, and thence to Tanganyika and northwards along the frontier of the Belgian Congo to the Nile, thus touching in part his old area of investigation near Lake Kivu. The duration of the new expedition will probably be between one and two years. A considerable stay will be made in the district between Lakes Nyasa and Tanganyika, which it is proposed to traverse in all directions. Among other items, the ascent and geological investigation of the little-known Konde volcanoes near Lake Nyasa, as well as a visit to the Rukwa valley, are planned. The scientific collections are destined for the museums in Berlin, Brussels, and St. Petersburg.

AMERICA.

The Origin of Cliff Lake, Montana, is discussed by Prof. G. R. Mansfield, on the basis of personal observations, in the *Bulletin* of the Geographical Society of Philadelphia for April, 1911. The lake, which is about 4 miles long and has a narrow branching form, is sunk below the general level of the upland of South Central Montana, resting like a blue gem in a deep setting of white cliffs and evergreen timber. Since first described by Hayden, as "formed in a huge fissure in the volcanic rocks," it has been generally regarded as of volcanic origin, but Prof. Mansfield doubts the correctness of this view. He shows that the similar dip of the lava beds on both sides of the depression tells against the idea that the former were poured out from the latter, while the extreme youth of the cliffs as compared with the more mature forms of the plateau surface indicates that, even if a fissure, the depression is of later date than the lava beds. Its form and that of its walls is considered unfavourable to the fissure theory, while the absence of volcanic *débris* points in the same direction. The island in the lake, of which the conical form has been thought suggestive of volcanic origin, is found to consist of nearly flat-lying lava, resting, as elsewhere, upon gravels, and thus fits in appropriately on the supposition that the valley is due to erosion. North-west of Cliff lake is a smaller lake at a lower level, occupying part of the same valley, though the intermediate portion is blocked by *débris*, apparently due to landslips, beneath which the water passes from the higher to the lower lake. It thus seems probable that the lakes occupy portions of an old river valley, of which the drainage has been blocked by landslides. A point still awaiting explanation, however, is the reported existence of a sounding of between 500 and 600 feet near the north end of Cliff lake, and of other chimney-like holes in the eastern arm.

Geographical Excursion across the United States in 1912.—Next year the American Geographical Society celebrates its jubilee, and in connection with this event a transcontinental excursion for the purpose of geographical study is planned, under the leadership of Prof. W. M. Davis. Delegates from European Geographical Societies will be welcomed as participants. The exact dates of beginning and ending have not yet been fixed, but the start from New

York will take place some time in August, and the excursion will conclude in October, its duration being six or seven weeks. A special train will be provided, with all the comforts necessary to relieve the monotony of the journey, while this will also be broken by halts on the way, permitting short excursions on foot or otherwise. The outward route is at present planned so as to include (among many other points of geographical interest) the highlands and gorge of the Hudson, Niagara, the shore-lines of old lakes in Ohio, the southern end of Lake Michigan and its artificial outlet into the Mississippi system, the upper Mississippi and Missouri, the Yellowstone cañon and National park, the Rockies of Southern Montana, the Cascade range, Seattle and Puget sound. The return will probably be made by a more southerly route, through Idaho, Nevada, Utah, New Mexico and Arizona, and possibly also taking in San Francisco. This will give opportunity for the examination of many features of interest connected with the Columbia, Snake, Arkansas, and Colorado rivers, the Wasatch and other ranges, the ancient shore-lines of Lake Bonneville, and the various plains and deserts of the States traversed. From Kansas city, on the Missouri, the route will be by St. Louis, Nashville, Chattanooga, the Blue ridge, etc., to Washington, and thence by the Falls of the Potomac, the Susquehanna, and across the Alleghanies to New York. The American members of the excursion will, as far as possible, act as guides to the European visitors, and while the features of the landscape will be the first objects of observation, attention will also be directed to the farming and other industries, and other economic aspects of the regions traversed. All correspondence is to be addressed to Prof. Davis, c/o the American Geographical Society, New York.

The Peru-Bolivia Boundary.—We have received from the Foreign Office a copy and translation of the protocol signed at Lima on April 15, 1911, by which the exact proceedings to be adopted by the delimitation commissions appointed by the two governments to carry out the survey and marking of the frontier are laid down.* The portion of the line to be dealt with immediately is divided into four sections, the course of each of which is defined in the protocol. The further portion, between the Madre de Dios and the Acre, will not be dealt with until a settlement is arrived at in respect of the limits on the Manuripi river as provided for in the protocol signed on March 30, 1911. Meanwhile, this region is to be specially studied by a sub-commission. Precise instructions are given as to the fixing of boundary marks, the surveys to be carried out, the making of a map, and so on. In case of any difficulty arising which cannot be settled by negotiation, the ultimate decision is to rest with this Society, whose decision is to be final.

AUSTRALASIA AND PACIFIC ISLANDS.

The most Northern Camp of Burke and Wills.—The latest volume of the *Queensland Geographical Journal* contains the report of a paper read by Dr. J. P. Thomson early in 1910, describing his expedition of 1909 to the Gulf of Carpentaria for the purpose of examining a site on the Bynoe river (the main branch of the lower Flinders), where certain marked trees had been discovered by Mr. T. Graham, giving cause for supposing that the spot represented the most northern camp (No. 119) of the ill-fated Burke and Wills expedition across the Australian interior in 1860. The identity of this point has always been in doubt; for though, according to King (the sole survivor of

* See *Journal*, vol. **35**, p. 597; vol. **37**, p. 216. The general course of the frontier is shown on the Society's map of Southern Peru and Northern Bolivia (vol. **36**, p. 512).

the expedition), it was supposed by Wills to be on the Albert river, good reason was shown by Baron von Mueller, who spoke from personal knowledge of this part of Australia, for believing it to have been on the Flinders, over 70 miles east of the Albert. In his evidence before the Commission of Inquiry, King said that at Camp 119, on the east bank of a tidal river, "there were some small box trees. We cut the bark 18 inches by 4, and cut the letter *B* on the trees. Some fifteen trees were marked, but with no date." According to Wills's journal, the ground thereabouts being impracticable for the camels owing to the heavy rains, he and Burke tried to push on to the sea on foot, taking three days' provisions on a pack-horse. The land was, however, so soft and rotten that they were obliged to return without a sight of the ocean, after pushing 15 miles farther north. Mr. Frederick Walker, who led an expedition to the Gulf of Carpentaria in search of the missing explorers, discovered clear traces of their passage near the junction of the Flinders with the Bynoe, including a tree marked *B. CXIX.*, but did not entirely satisfy himself that this marked the site of the most northern camp. Dr. Thomson—who reached the spot *viâ* Normanton, after crossing Northern Queensland by the railway from the east coast to Croydon—found the marked trees on the east bank of the Bynoe, one of the most prominent being a coolibah, with the inscription, "F. W., 12th January, 1862." This was probably, therefore, the spot where Walker found the tree marked *B. CXIX.* Fifteen other marked trees were found, five being coolibahs, the rest gutta-percha trees, none exceeding 3 feet in girth. The choice of such small trees for marking seemed somewhat singular, as comparatively large specimens were scattered about the locality. In one case only—that of a coolibah—was any actual trace of an inscription discernible, the gutta-percha trees in particular being soft and the wood not durable. But on the one tree alluded to the outlines of the letter *B*, though faint, were clearly traceable. Dr. Thomson considered that the number of the camp (*CXIX.*) originally followed, but that it has since been obliterated. In any case, there is little doubt that the spot is to be identified with the most northern camp, the surroundings agreeing well with King's description. Dr. Thomson's paper gives some interesting details as to the economic condition of the parts of Northern Queensland visited by him.

The Federal Territory in Australia.—A study of the physical features of the Federal territory at Canberra (see vol. **35**, pp. 318–320) was made last year by Mr. Griffith Taylor, under official instructions. Mr. Taylor, who is Physiographer to the Commonwealth Meteorological Bureau, gives the results in Bulletin No. 6 of that department, describing minutely the topography of the area, and drawing conclusions as to the course of evolution of the present surface. The Lake George area to the east, of which a similar survey had previously been made by Mr. Taylor, is also taken into consideration, as it presents analogies with the Canberra territory, which help to an understanding of the history. Lake George (now generally dry) occupies a closed basin, consisting for the most part of plains sloping gently from east to west, but bounded to the west by a steep wall, the Cullarin range, only partially breached by Geary's Gap, abreast of the middle of the lake. South of Lake George there are similar plains sloping to the west, drained by the upper Molonglo, but this river has succeeded in completely breaching the ridge of higher ground, which it traverses by a narrow defile. Further west the basin of the upper Murrumbidgee shows a generally similar configuration, the ground sloping from east to west to the main channel, which flows at the foot of another steep escarpment, furrowed by streams of youthful age, and broken through by the gorges

of the chief western tributaries of the Murrumbidgee. The physical history of the region seems to have been dominated in recent geologic times by the formation of two lines of fault, which have given rise to the two scarps above referred to. Before this the topography had reached a fairly mature stage, though some of the heights had not been worn down to the level of the plains, but still stand up as monadnock ridges. Mr. Taylor supposes the block between these faults (with Canberra near its centre) to have appreciably tilted, increasing the westerly fall of the surface, and bringing the Murrumbidgee drainage to the foot of the western scarp. That no similar river was formed at the foot of the eastern scarp is due to its nearness to the position of the main divide. A number of changes in the river systems have resulted from these movements. Thus the Lake George basin was cut off from the Yass, of which it once formed the head, while probably also the upper Wollondilly of the present day formed the head of the ancient Lachlan, as also the Shoalhaven that of the ancient Wollondilly. More extensive changes have resulted in the system of the Murrumbidgee, the modern headwaters of which have been captured from an ancient southward-flowing system, as is indicated by the reversed direction of many of its branches, forming "boat-hook" bends or "crossed forks." The gap through which the river flows at Tharwa marks the position of the old east-west divide. In the last part of the paper Mr. Taylor traces the influence of the surface features on the economic aspects of the district, especially on its communications, which have been affected, now favourably, now unfavourably, by the formation of the fault-scarps. The rainfall is also markedly affected by the topography, one of the striking features being a narrow north-to-south belt with rainfall below 22 inches (contrasting with one of from 30 to 50 inches on either side), which corresponds with the large continuous depression running southwards from Cowra towards Bass strait.

The Franz Josef Glacier, New Zealand.—This great glacier, little known until recent years, but surpassed by only one other in the Alps of New Zealand, was the object of a careful examination during 1909 and 1910 by officers of the New Zealand Geological Survey. In the former year Mr. R. P. Greville made a topographical survey both of the main glacier and of several of its tributaries, as well as of the great snow-fields at its head. In 1910 a further examination was made by the late director of the Survey, Dr. J. M. Bell, and Mr. J. M. Clarke. On the basis of this work a full description, with maps and illustrations, has been issued by the Survey. Like other glaciers of the humid west coast, the Franz Josef is remarkable for the low level (692 feet) to which its front descends, and for the comparative absence of *débris* from the surface; the latter fact being due in part to the more rapid fall (as compared with the eastern glaciers), and the resulting crevasses; in part to the different texture of the rocks. One of its most striking features is the great ice-fall at the upper end of the trunk portion. At present its length is 7½ miles, but in the Pleistocene period it deployed on to the coastal plain, and uniting with other ice-streams formed a vast piedmont ice-sheet. Although it has since retreated greatly, the movement has not been constant, and there has been a remarkable advance within the past few years. At present the frontal face rises in a magnificent cliff of ice, hundreds of feet in height, forming lobes separated by the upstanding Harper and Park rocks. There are many tributary valleys, some occupied by ice alone, while in other cases a stream issuing from a small glacier impinges on the main glacier.* The

* These tributary valleys would seem deserving of special study in connection with the question of the origin of hanging valleys.

snow-fields at the head of the Franz Josef glacier form an almost continuous sheet of *névé* occupying 4758 acres, and are exceeded in area in New Zealand only by those of the Fox glacier. The slopes on either side of the glacier are mainly of solid rock, scree-slopes being rare. The broad, straight, U-shaped valley of the Waiho below the glacier, with its precipitous sides and truncated spurs, is held to indicate graphically the influence of glacial corrasion in the past. At present the ice flows in a trough much larger than it requires, and little wearing away of the underlying rocks probably takes place.

Anthropological Expedition to New Guinea.—The Committee for Anthropology at Oxford will despatch an expedition for anthropological research to the still imperfectly known D'Entrecasteaux group, off the eastern end of New Guinea, during the autumn. It will be in charge of Mr. D. Jenness of Balliol, who before proceeding to Oxford won distinction at the University of New Zealand, besides acquiring practical experience of life in the bush. His base of operations will be on Goodenough island, whence he will carry out a general survey of the whole group.

POLAR REGIONS.

German Antarctic Expedition.—The ship of this expedition, the *Deutschland*, which sailed from Germany in May, is reported to have shown excellent qualities during the voyage to the Azores. Various oceanographical and physical observations were made during the passage, which has since been continued towards Buenos Aires, which port will probably be reached during September. Lieut. Filchner, who remained in Germany to complete the preparations, is expected to reach Buenos Aires in August, in which month the last part of the equipment, including the ponies and dogs, will be despatched by mail steamer.

MATHEMATICAL AND PHYSICAL GEOGRAPHY.

Preliminary Steps in Aviation Cartography.*—The first trials of dirigible balloons demonstrated the need of special aeronautical maps. It was proposed by Hermann Moedebeck that all objects which would facilitate orientation should be indicated by conventional signs, and the formation of an international commission for the compilation of such maps has already led to the publication of the first sheet with aeronautic signs, namely, the Cologne sheet of the German Aeronautic Union. Of national maps may be mentioned the 'Carte Aéronautique de la France' of the Soc. Fr. de Navigation aérienne, compiled under the supervision of the engineer Desmond on the scale of 1 : 200,000. Both of these are hypsometrical maps. Aerial navigation is evidently a rash and dangerous feat, especially in mountainous countries, unless the aeronaut has a map before him showing clearly the configuration of the surface over which he is moving in a relatively low flight. Military maps, answering fully the purpose for which they are intended, show only important differences of gradient, and the fine Swiss maps afford only a general idea of mountain forms, and not directly of differences of height. How important it is, especially during the rapid flight of an aeroplane, that the aviator should be able to grasp the situation with an instantaneous glance! and how is that possible with existing maps which can only be read with some trouble in the study? The aeronauts have a right to demand that their maps should represent the more striking features of the landscape with a perspicuity equal to the original, and therefore

* Condensed translation of a communication from Dr. Karl Peucker, November, 1910.

aeronautic maps must reproduce the aspect of the country more accurately than ordinary maps. The surface dividing land from air is to the aeronaut what the coast-line is to the mariner, and elevations and depressions should be as distinctly and clearly shown on an aviation map as capes and peninsulas on a sea-chart. As marine navigation requires general charts, rhumb charts, and harbour plans, so aerial navigation demands general maps, route maps, and plans of landing-places. The general hypsometrical map should show all three, while with increasing scale the faithfulness to nature should be carried into greater detail, landing plans requiring, indeed, the precision of a photograph. Those who are interested in the question ought to pay attention to the progress made in Vienna in photo-cartography on the one hand and representation of the configuration by colours on the other. Photocartography may be briefly defined as the photomechanical transformation into maps of panoramic surveys of the country from a balloon. Woodbury was probably the first to construct apparatus for such panoramic surveys in 1881, and Colonel Capper and Mr. Brewer have recently made similar instruments; while in other countries, especially France, experiments have been made. The Scheimpflug panoramic instrument is much superior to all that have preceded it, not only possessing greater capabilities, but being also much smaller and lighter. Another aid to the photocartographic process is the photoperspectograph, which takes the place of a mechanical drawing machine, which, just as in the recently described Orell method, projects the photographic image on to a horizontal plane. But the Scheimpflug instrument is no mere pantograph, but converts the original photographs by a photographic process into a horizontal bird's-eye perspective. The great defect is now the want of uniformity in the scale, and this is remedied by the stereocomparator, which automatically inserts on the photographs the line of altitude. The land surface, which is reproduced on a larger scale the higher it is and therefore the nearer to the balloon, can be reduced to zones of uniform scale, and this, too, is effected by photography. Thus an orthogonal projection is evolved from the perspective views, and now the cartographic work can be commenced. It is necessary to restore the appearance of relief to the flattened form, the configuration now reduced to a ground-plan being made apparent by the means of the optical values of colours. Thus are produced those equivalent space maps necessary to navigation in space. For landing-places rapid orientation is a principal necessity, so that the traveller in the air shall know what points to make for or avoid in order to descend safely. The more the photo-map is reduced, the more the hand must be employed in rendering conspicuous essential and suppressing unnecessary details; while the rendering conspicuous the true differences of height by means of colour completes the adaptation of a faithful representation of nature to practical use. As the scale of 1 : 200,000 commends itself, photocartography would be especially suitable for regions outside the civilized world, and would be an excellent method of survey for the colonies. Better results could be obtained in a few years, and with a moderate outlay, than by any other method during centuries and at the cost of millions of pounds, and an earlier realization of the project of geographers for a universal map would be facilitated, which, converted into a coloured relief map, would yield a general map for aeronauts. An international agreement as regards uniform aeronautic route maps and landing plans is very necessary, and might lead to the co-operation of cartographers of all countries in the promotion of a uniform and rational production of maps of all kinds.

The Snow-line in the French Alps and Caucasus.—Two recent studies of

the general course of the snow-line, on the basis of the best existing maps, have to do with the French Alps and Caucasus respectively. The former region is dealt with by V. Paschinger in the *Zeitschrift für Gletcherkunde* for January last. The writer, following the method adopted by Partsch, first tabulates respectively, for each group of the French Alps, the lowest peaks and ridges covered by ice and snow, and the highest almost or quite free from a snow-covering; an intermediate figure between the mean altitudes of the two categories giving the approximate height of the snow-line for each group. The general deductions are as follows: the snow-line in the French Alps lies between 2700 and 3200 metres (8850 and 10,500 feet), rising in general from west to east. This is explained by the fact that the western part is under the influence of an oceanic climate, while east of the main weather parting the continental climate of Northern Italy makes itself felt. There is both a diminution of precipitation and a rise of temperature from west to east, and these two factors operate nearly equally to raise the snow-line in the latter direction. The influence of general elevation (*Massenerhebung*) is also a factor to be reckoned with, as is seen in the rise of the snow-line about Mount Pelvoux, the Gran Paradiso, and Mount Blanc. The study of the Caucasus, on similar lines, is made by A. Von Reinhard, in No. 5 of the *Zeitschrift* of the Berlin Geographical Society for 1911. In this case there is a still more marked rise of the snow-line from west to east, the difference amounting to no less than 1000 metres (3300 feet). A rise is also noticeable from the outer zone inwards, again in accordance with the principle of *Massenerhebung*. It is by no means generally true that the line is lower on the south than on the north side of the chain, the chief difference lying in the fact that, while the line rises evenly from east to west on the south side, much more irregularity prevails on the north. The highest position of the line occurs not on the main crest but on the northern spurs of the Gestola-Dychtau group. In Suanetia, on the south side of the range, the line runs some 500 metres (1650 feet) lower. Towards the eastern end of the range the line is found to run 100 to 250 metres (300 to 800 feet) lower on the north than on the south side of each group and ridge.

The Great-Wind Regions on the Oceans.—These areas have been carefully measured by Dr. R. Lütgens, who gives the results in the fifth number of the *Annalen der Hydrographie* for 1911 (p. 265). The wind areas were laid down, on the basis of the German official charts and sailing directions on equal area maps, and the measurements made on these. Only the great wind regions were taken into account—those of the trades, the Asiatic monsoons, and equatorial calms for the tropical zone, and of the west winds in temperate latitudes, the remaining portions of the oceans being classed as sub-tropical (between the belts of trades and, roughly, 40° north and south) and polar (above 60° in either direction). The limits cannot of course be fixed with great precision, but the figures obtained are of interest as giving the relative sizes of the several regions with some degree of approximation. Comparing the Atlantic and Indian oceans (up to 40° of latitude in each case), the most striking fact is the smallness of the belt of equatorial calms in the Atlantic—less than 4000 square kilometres as against nearly 13,000 in the Indian ocean; the other zones showing a general agreement. In the Pacific, though most of the areas are naturally much greater (the belt of south-east trades forming a continuous one of 40 million square kilometres) the belt of calms hardly exceeds that of the Indian ocean. The belt of westerly winds is naturally much greater in the southern than in the northern hemisphere, owing to the excess of the water surface in the former. It reaches nearly 57 million square kilometres, as

against 28·4 in the north. Taken together, the moonsoons, trades and equatorial calms occupy 46 per cent. of the water surface of the globe, the trades alone being responsible for 31 per cent. The west winds blow over 24 per cent. of the surface, while the region of calms represents only 9 per cent.

GENERAL.

Tears as a Mode of Greeting.—In his lecture before the Society on July 3, describing the recent British expedition to Western New Guinea, Captain Rawling referred to the strange and disconcerting behaviour of some of the natives met with, who on first meeting the explorers welcomed them with floods of tears. In connection with this, attention may be called to a recent discussion of the custom, as occurring in other parts of the world, by the German traveller and ethnologist, Dr. G. Friederici. In a first paper (*Globus*, vol. 89, p. 30), this writer, from an examination of a number of early accounts of travel in America, concluded that there were two distinct groups of peoples on that continent among whom the custom had once been current, one in North, the other in South America. He also pointed to a third zone of occurrence of this mode of greeting—among the Andamanese and other Negroid inhabitants of South-Eastern Asia and Australasia. The first origin of the custom he attributed to an exaggerated feeling of sympathy for the hardships suffered by strangers in their journeys through pathless wildernesses or dangerous seas. In a later paper, published separately in 1907 (Leipzig: Simmel & Co.), Dr. Friederici replied to criticisms of his former views, and gave further notes on the distribution of the custom, which, on further examination of old or recent authorities, proved to have been once so widely spread over the American continent as to cease to be a singularity in any one locality. The first mention seems to be in the 'Diario da Navegação' of the Portuguese Pero Lopes de Souza, in 1530-32, in connection with his visit to the peoples on the Uruguay. That the custom should recur in so widely separated a region as Australasia seems one more proof of the way in which similar customs may originate independently under similar external conditions.

Adam of Bremen and his Geographical Notions.—A discussion of this subject has lately been undertaken by Dr. Bjørnbo, the well-known curator of the Royal Library at Copenhagen.* In order to obtain a clear notion of Adam of Bremen's conception of the northern parts of Europe, the writer has compiled a map from the author's text. He compares the distances given between various points, which give an average of 50 kilometres for a day's journey on land, while those by sea differ too considerably to give any reliable measure. Ireland lies to the north of Great Britain, while Iceland and Greenland are said to lie at about equal distances from the coast of Norway. The exact position of Winland, which has been assumed by some to be the Vinland in America, is not exactly defined; but as it is mentioned after Greenland, which lies north of the line where Scandinavia abuts on the Riphæan mountains, it is natural to assume that Adam's Winland lay east of Greenland. Moreover, beyond it lay the murky frozen Arctic ocean. Adam seems, in a passage much of which is borrowed from Bede, to accept the spherical form of the Earth, but his cartographical construction was no doubt adapted to the T-shaped maps of the world in vogue in his time. Another attempt to reproduce Adam von Bremen's description in cartographical form was published in the

* 'Adam af Bremens Nordensopfattelse.' Af Axel Anthon Bjørnbo. Kjøbenhavn: H. Thieles Bogtrykeri. 1910.

Hansische Geschichtsblätter by Hermann Krabbo, when Dr. Bjørnbo's essay was ready for press, and in the main the results agree, so that the advantage of this method of investigation is thereby confirmed. Adam of Bremen's influence on later cartography is also noticed by the author.

The End of Darwin's "Beagle."—Shortly after the Darwin celebration in 1909, a Japanese correspondent gave, in *Nature* of December 9 of that year, some particulars respecting a vessel bearing the name *Beagle*, which, after being sold by the British Admiralty, had been eventually purchased by the Japanese Naval Department, and used for some time as a training-ship. This was supposed by the correspondent to have been the famous *Beagle* of the 'Naturalist's Voyage.' That he was mistaken is pointed out by Mr. F. P. Purvis in *Nature* for June 1 of this year, on the strength of information supplied by Mr. N. E. Smith, of the Comptroller's Department of the Admiralty. It appears that Darwin's *Beagle*—a 10-gun brig-sloop built in 1820—was sold in 1870, after having served for some years as watch-vessel at Southend. The *Beagle* which went to Japan was a first-class gun-vessel built in 1854, and particulars of the sale of this at Hong-kong, in 1863, are given in *Nature* of July 13 by Mr. H. C. Shoosmith, who himself took her over to Japan with a view to reselling her there.

A Collection of Meteorological Photographs.—We are asked to state that the United States Weather Bureau is forming, in its library at Washington, a collection of meteorological photographs, and will welcome additions thereto from all parts of the world. The collection will include views of meteorological observatories, etc., pictures of apparatus, portraits of meteorologists and views of their homes, photographs of meteorological phenomena and their effects, and of old pictures illustrating the same. Persons willing to present such pictures or to give them in exchange for publications of the Bureau are requested to address them to the Chief of the U.S. Weather Bureau, Washington, D.C., marking them "Library." So far as practicable, information about each picture should be noted on the back.

OBITUARY.

Major-General Robert von Sterneck.

Major-General von Sterneck, who died in November, 1910, was formerly director of the Geodetic Section of the Military-Geographical Institute in Vienna, and had attained an international reputation for his pendulum apparatus and the determinations of gravity carried out by its aid. Born at Prague in 1839, he entered the army at the age of twenty, and took part almost immediately, as lieutenant, in the battles of Magenta and Solferino. In 1862 he was appointed to a post in the Military-Geographical Institute, and maintained his connection with that body until 1906. Since 1882 he had acted as Commissioner for Austria-Hungary in the International Geodetic Association, and as such had carried out determinations of latitude and azimuth at fifty-nine stations, introducing improved methods into the operations. With the half-second pendulum constructed by him, and now in use in all civilized countries, he made gravity-determinations at no fewer than 544 stations. He also invented a tide-gauge for the exact determination of mean sea-level, and by its aid carried on the tidal investigations in the Adriatic, to which reference has lately been made in the *Journal* (vol. 33, p. 86). His geodetic work extended to the Balkan peninsula, where between 1871 and 1874 he carried out determinations of position and altitude

both in Bosnia and Hercegovina, and in Servia and Bulgaria. Papers from his hand are to be found both in the publications of the Vienna Academy of Sciences, and to a still larger extent in the *Mitteilungen* of the Military-Geographical Institute.

Henry Harrisse.

Henry Harrisse, known to all students of the history of geography for his works on the discovery of America and other subjects connected with the evolution of geographical and cartographical knowledge, died last year in Paris at an advanced age. The following details are taken from a notice written by M. Cordier for the *Bulletin de Mer[illegible]* of which we have received a copy. There is reason to believe that he was [illegible] Jewish extraction, and that he was born in Paris about 1830. He emigrated to the United States when quite a young man, and devoted himself at first to the study of literature and philosophy, but afterwards studied law, qualifying as an advocate. In 1864 he became acquainted with Mr. Samuel Barlow, who had then just bought the library of Colonel Aspinall, and this turned his interests in the direction of the bibliographical studies to which his energies in the latter part of his life were so largely directed. The first important outcome of these studies was the *Bibliotheca Americana vetustissima*, published in 1866, and supplemented by a second volume in 1872, which gave an account of works relating to America printed between 1492 and 1551. Of his later works, the most important next to that on the Discovery of America, already referred to, was his 'Discovery and Cartographical Evolution of Newfoundland' (see *Journal*, vol. 19, p. 625).

MEETINGS OF THE ROYAL GEOGRAPHICAL SOCIETY, SESSION 1910-1911.

Fourteenth Meeting, May 29, 1911.—The Right Hon. Lord CURZON OF KEDLESTON, P.C., G.C.S.I., G.C.I.E., etc., President, in the Chair.

ELECTIONS.—*James Cossar; Rev. George Edmundson; Charles Burton Fairfax; Andrew Oswald Gatley; Charles Malcolm Barclay Harvey; D. L. Kerr; Alexander Livingstone Nairn, B.A.; Arthur George Murray Smith; H. Owen Smith.*

The paper read was:—

"The Geographical Conditions affecting the Development of Canada." By Prof. W. L. Grant.

Sixteenth Meeting, July 3, 1911. Colonel Sir T. H. HOLDICH, K.C.M.G., etc., Vice-President, in the Chair.

ELECTIONS.—*Thomas Maitland Ainscough; E. B. Bailey; Philip A. Barendt; Captain F. St. J. Blacker; Victor Macomber Cutter; Captain W. H. Benett-Dampier; Erasmus Darwin; F. W. de Valda; Arthur L. Dickinson; Wilfrid B. Edmunds; J. M. Forman; Rev. Wm. D. Graham; Captain J. R. Hutchison; A. F. P. Knapp; J. L. Landon; Lieut. Kenneth Mason, R.E.; Ian Burn Murdoch (32nd Sikh Pioneers); H. H. The Maharajah of Patiala; Arnold Henry Perry; G. H. Ridout; Dr. Walter Saise; Captain G. G. M. Tyrrell (5th Lancers); Frederick George Whittick; Harry Wood.*

The paper read was:—

"Explorations in Dutch New Guinea." By Captain C. G. Rawling.

RESEARCH DEPARTMENT.

April 27, 1911.—Prof. J. L. MYRES in the Chair.

"Recent Progress in Geodesy." By A. R. Hinks.

June 15, 1911.—Prof. J. L. MYRES in the Chair.

"Investigation of Rivers, Fourth Report." By Dr. A. Strahan.

GEOGRAPHICAL LITERATURE OF THE MONTH.

Additions to the Library.

By EDWARD HEAWOOD, M.A., *Librarian*, R.G.S.

The following abbreviations of nouns and the adjectives derived from them are employed to indicate the source of articles from other publications. Geographical names are as a rule written in full:—

A. = Academy, Academie, Akademie.
Abh. = Abhandlungen.
Ann. = Annals, Annales, Annalen.
B. = Bulletin, Bollettino, Boletim.
Col. = Colonies.
Com. = Commerce.
C.R. = Comptes Rendus.
E. = Erdkunde.
G. = Geography, Géographie, Geografia.
Ges. = Gesellschaft.
I. = Institute, Institution.
Iz. = Izvestiya.
J. = Journal.
Jb. = Jahrbuch.
Jber. = Jahresbericht.
k.k. = kaiserlich und königlich.
M. = Mitteilungen.
Mag. = Magazine.
Mem. (Mém.) = Memoirs, Mémoires.
Met. (mét.) = Meteorological.
P. = Proceedings.
R. = Royal.
Rev. (Riv.) = Review, Revue, Rivista.
S. = Society, Société, Selskab.
Sc. = Science(s).
Sitzb. = Sitzungsbericht.
T. = Transactions.
Ts. = Tijdschrift, Tidskrift.
V. = Verein.
Verh. = Verhandlungen.
W. = Wissenschaft, and compounds.
Z. = Zeitschrift.
Zap. = Zapiski.

On account of the ambiguity of the words *octavo*, *quarto*, etc., the size of books in the list below is denoted by the length and breadth of the cover in inches to the nearest half inch. The size of the *Journal* is 10 × 6½.

A selection of the works in this list will be noticed elsewhere in the "Journal."

EUROPE.

Adriatic—Bibliography. *G. Jber. Österreich* **8** (1910): 33–69. **Merz.**

Die meereskundliche Literatur über die Adria mit besonderer Berücksichtigung der Jahre 1897–1909. Das Meeresbecken, Hydrographie, Meteorologie. Von Dr. Alfred Merz.

A review, not merely a list, of the literature.

Alps—Geology. **Schweiz. Geologischen Kommission.**

Beiträge Geol. Karte Schweiz, N.F., Lief. **23** (1909): pp. xiii. and 248.

Beiträge zur Geologie des Unterengadins. Von Dr. Chr. Tarnuzzer und Prof. Dr. U. Grubenmann. *Maps and Profiles.*

Alps, Western—Glaciers. *Riv. G. Italiana* **18** (1911): 46–60. **Monti.**

Primo saggio di nuove ricerche sulle oscillazioni dei ghiacciai del Gran Paradiso. Di V. Monti. *Illustrations.*

Austria—Carinthia. *G. Jber. Österreich* **8** (1910): 201–245. **Polscher.**

Die Hochseen der Kreuzeckgruppe. Von Dr. Heinrich Polscher. *Sketch-maps, Sections, and Illustrations.*

Austria-Hungary. *B. Hungarian G.S., Int. Ed.* **37** (1909): 265–274. **Havars.**

Der Trialismus im Lichte der Geographie. Von Dr. Rezsö Havars.

Discusses the present tripartite character of the Austro-Hungarian monarchy.

Austria—Karst. *Geol. Charakterbilder (Stille)* **1** (1910): Heft 3, 6 Pls. **Grund.**

Das Karstphänomen. Von A. Grund. *Illustrations.*

Austria—Karst. *G. Jber. Österreich* **8** (1910): 70–112. **Krebs.**
Die landeskundliche Literatur der österreichischen Karstländer in den Jahren 1905–1908 (1909). Von Dr. Norbert Krebs.

Gives an indication of the nature and contents of the separate publications.

Balkan States. **Jaekel.**
The lands of the tamed Turk, or the Balkan States of to-day. A narrative of travel through Servia, Bulgaria, Montenegro, Dalmatia, and the recently acquired Austrian provinces of Bosnia and the Herzegovina; with observations of the peoples, their races, creeds, institutions, and politics, and of the geographical, historical, and commercial aspects of the several countries. By Blair Jaekel. Boston, [Mass.]: L. C. Page & Co., 1910. Size 8 × 5, pp. xiv. and 296. *Map and Illustrations. Presented by the Author.*

Baltic. *Conseil Perm. Explor. Mer; Publ. circonstance*, No. 52 (1910): pp. 190. **Gehrke.**
Beiträge zur hydrographie des Ostseebassins. Von Johan Gehrke. *Diagrams.*

Central Europe—Böhmerwald. *G. Jber. Österreich* **8** (1910): 113–170. **Puffer.**
Der Böhmerwald und sein Verhältnis zur innerböhmischen Rumpffläche. Von Dr. Lorenz Puffer. *Map and Sections.*

Corsica. *Ann. de G.* **20** (1911): 44–51. **Lucerna.**
Les anciens glaciers de la Corse et les oscillations pleistocènes de la Méditerranée. Par R. Lucerna.

Denmark. *Oversigt K. Danske Videnskabs-S. Forhandl.* (1911): 25–39. **Steenstrup.**
Quelques recherches sur la rivière de Kongeaa. Par Johannes Steenstrup. *Sketch-map.*

Eastern Europe. **Kreutzbruck v. Lilienfels.**
Petermanns M. **56** (1910) 2 Halbbd.: 281–286.
Der türkisch-griechische Kriegsschauplatz. Ein militärgeographische Studie von Major O. Kreutzbruck v. Lilienfels. *Maps.*

France—Alps. *Z. Gletscherkunde* **5** (1910–11): 211–221. **Paschinger.**
Die Schneegrenze in den französischen Alpen. Von Dr. Viktor Paschinger. *Sketch-map.*

See note on p. 210.

France—Brittany. *B.S.G. Lille* **55** (1911): 10–34. **De Jaeghere.**
Excursion sur les côtes de Bretagne. Par M. Paul De Jaeghere. *Illustrations.*

France—Calvados—Coast. *B.I. Océanog. Monaco*, No. 199 (1911): pp. 10. **Sudry.**
Densité, température, coloration de l'eau de mer et courants sur la côte du Calvados pendant l'été 1910. Par L. Sudry.

France—Hydrography. *La G., B.S.G. Paris* **23** (1911): 193–196. **Glangeaud.**
Migration de la ligne de partage des eaux dans la Chaîne des Puys. Un réseau hydrographique fossile. Par Ph. Glangeaud. *Diagram.*

France—Marine Flora. *B.I. Océanog. Monaco*, No. 202 (1911): pp. 14. **Cépède.**
La Flore planctonique du Pas de Calais en 1906. Par Dr. Casimir Cépède.

France—Rhone. *C.R. IX^e Congrès Int. G.* **3** (1911): 77–88. **Clerget.**
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Central Asia. *B.S.G. Com. Havre* **27** (1910): 73–83, 121–135. **Pelliot.**

Trois ans de Mission dans la Haute-Asie. Par Paul Pelliot. *Sketch-maps.*

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L'irrigation dans l'Asie Centrale et la migration des peuples. Par le Professeur Dr. Jenö de Cholnoky.

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The Proposed Trans-Persian Railway. By Lieut.-Colonel A. C. Yate. *Sketch-map.*

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Die Volksdichte in der oberen Gangesebene. Von Dr. Paul Böllert. *Map.*

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An account of this earthquake was given in the *Journal* for February last, p. 180.

Siam—Anthropology. **Hosseus.**
Die Bedeutung der Bambusstaude auf Grund eigener Studien in Siam. Von Dr. Carl Curt Hosseus. (From *Archiv für Anthropologie.*—Neue Folge, Band x. Heft I.) Brunswick, 1911. Size 11 × 8½, pp. 55–73. *Presented by the Author.*

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Reisen und Forschungen im westlichen Kleinasien. I. Das westliche Mysien und die pergamenische Landschaft. Von Dr. Alfred Philippson. *Map and Illustrations.*

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Les points d'eau et la région nord de l'erg du Gourara. Par H. Priou. *Map.*

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Montagnes d'Algérie. Mouzaïa, Aurès, Djurdjura. [Par le Général Bernard.]

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Du Congo à l'Ubangi: mon deuxième voyage dans l'Afrique centrale. Par Franz Thonner. Brussels: Misch & Thron (Paris: M. Rivière), 1910. Size 10 × 7, pp. xii. and 126. *Maps and Illustrations. Price* 12 *fr. Presented by the Publishers.*

A German edition has also appeared (see vol. 37, p. 625).

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Description of Boundaries in Naivasha, Tanaland, Nyanza, Jubaland, Seyidie, Ukamba, and Kenya Provinces. (Extract from *The Official Gazette of the East African Protectorate*, vol. 13, No. 268, January 1, 1911.) Nairobi, 1911. Size 13½ × 8½, pp. 9–11.

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Notes on Temperature at Alexandria. By J. I. Craig.

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Le Commerce de l'ancienne Egypte avec les nations voisines. Par le professeur Edouard Naville.

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The Underground Waters of the Oasis of Kharga. By H. J. Llewellyn Beadnell.

A reply to views expressed by Mr. G. W. Grabham in the same journal.

Egypt—Nile flood. *Cairo Sc. J.* **5** (1911): 29–36. **Hughes.**

Note on the amount of Silt carried by the Nile during the floods of 1908 and 1910. By Frank Hughes. [See *Journal*, vol. 37, p. 663.]

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On some methods of predicting the Nile Flood, taken from Arab Histories. By Mohammad Kasim.

French Guinea—Railway. *La G., B.S.G. Paris* **23** (1911): 214–218. **Paulin.**

Le Chemin de fer de la Guinée. Par Honoré Paulin. *Map.*

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De l'Atlantique au Tchad et au Borkou (Mission Tilho). Conférence faite le 16 Mars 1910, à la Société de Géographie d'Alger et de l'Afrique du Nord, par le Lieut. Maurice Mercadier.

German East Africa—Railway. *Deutches Kolonialblatt* **22** (1911): 273–276. ———

Die Ostafrikanische Mittellandbahn Daressalam—Morogoro—Tabora, und ihre Fortführung zum Tanganyika-See. Von F. B. *Map.*

Noticed in the May number, p. 563.

German South-West Africa. *M. Deutschen Schutzgebieten* **24** (1911): 30–42. **Range.**

Das Lüderitzland. Von Dr. Paul Range. *Maps and Illustrations.*

An excellent general account of the geology and geography of the district.

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Bericht über eine Bereisung des Ostgrenzbietes der Residentur Adamaua im Jahre 1909. Von Hauptmann Kurt Strümpell. *Illustrations and Diagrams.*

Kamerun—Rainfall. *M. Deutschen Schutzgebieten* **24** (1911): 1–15. **Langbeck.**

Niederschlagsregistrierungen am Kamerungebirge vom Jahre 1909–10, unter Berücksichtigung der täglichen Regenverteilung in den Tropen. Von K. Langbeck.

Madagascar—Historical. *J. Asiatique* **15** (1910): 281–330. **Ferrand.**

Les Voyages des Javanais à Madagascar. Par Gabriel Ferrand.

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La densité de la population à Madagascar. Par le Lieut. E. de Martonne. *Sketch-map.*

Noticed in the June number (vol. 37, p. 664).

Morocco. *B.S.G. Oran* **30** (1910): 529–575. **Lecocq.**

Le Maroc occidental. Par Prof. Adré Lecocq.

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Nigeria—Railway. *R. Engineers J.* **13** (1911): 241–260. **Mance.**

Baro-Kano Railway Construction. By Capt. H. O. Mance. *Sketch-map and Illustrations.*

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Das Abflussgebiet des Nil. Von Dr. Walter Pietsch. *Sketch-map and Diagrams.*

Sahara. *La G., B.S.G. Paris* **23** (1911): 238–240. **Cortier.**

Mission dans le Sahara du Capitaine Cortier. *Sketch-map.*

The map shows the network of routes surveyed by Cortier in 1906–7 and in 1908–10.

South Central Africa. **Colville.**

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Die gegenwärtige Lage im portugiesischen Grenzgebiet Deutsch-Südwestafrikas. Von K. Singelmann. *Map.*

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Alaska—Agriculture. *B. American G.S.* **42** (1910): 888–903. **Chubbuck.**

Alaska Agricultural Possibilities. By Levi Chubbuck. *Sketch-maps and Illustrations.*

Alaska—Seward Peninsula. *U.S. Geol. Surv. B.* **433** (1910): pp. 234. **Smith.**

Geology and Mineral Resources of the Solomon and Casadepaga Quadrangles, Seward Peninsula, Alaska. By Philip S. Smith. *Maps, Sections, Diagrams, and Illustrations.*

Canada. **Rogers.**

A historical geography of the British Colonies. Vol. 5, Canada. Part 3, Geographical. By J. D. Rogers. Oxford: Clarendon Press, 1911. Size 7½ × 5, pp. viii. and 302. *Sketch-map. Price 4s. 6d. Presented by the Publishers.*

Canada—Alberta—Coalfield. **Dowling.**

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Canada—Geological history. *J. Geology* **19** (1911): 57–60. **Spencer.**

On the focus of post-glacial uplift north of the Great Lakes. By J. W. Spencer. *Sketch-map.*

Canada—Islands. *C.R. Congrès Int. G.* **3** (1911): 172–180. **Shaw.**

Présentation par G. Lecointe d'un mémoire intitulé 'Plan for systematic research in the North American Archipelago.' By A. V. Shaw.

Canada—North-West Territories. **McInnes and Wilson.**

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Canada—Nova Scotia. **Willson.**

Nova Scotia: the province that has been passed by. By Beckles Willson. London: Constable & Co., 1911. Size 9 × 5½, pp. xii. and 256. *Map and Illustrations. Price 10s. 6d. net. Presented by the Publishers.*

Canada—Ontario—Geology. **Wilson.**

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Canada—Quebec. *B.S.G. Québec* **5** (1911): 24–34. **Rouillard.**

La région Labelle. Par Eug. Roulliard.

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Les dunes de Lachute. Par Avila Bédard.

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Synthesis of the Paleogeography of North America. By Edward Suess.

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Phytogeographic survey of North America: a consideration of the phytogeography of the North American continent, including Mexico, Central America and the West Indies, together with the evolution of North American plant distribution. By Dr. John W. Harshberger. (Die Vegetation der Erde: Sammlung pflanzengeographischer Monographien, herausgegeben von A. Engler und O. Drude. XIII. Bd.) Leipzig: W. Engelmann, 1911. Size 10 × 7, pp. lxiv. and 790. *Map and Illustrations. Price* 16*s.*

United States. *U.S. Geol. Surv., B.* **440** (1910): pp. 688. **Marshall.**

Results of Triangulation and Primary Traverse for the years 1906, 1907, and 1908. R. B. Marshall, Chief Geographer. *Map.*

United States—Arizona—Erosion. *J. Geology* **18** (1910): 742–763. **Robinson.**

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Geology and Water Resources of the San Luis Valley, Colorado. By C. E. Siebenthal. *Map, Plans, Sections, Diagrams, and Illustrations.*

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A quantitative study of the more conspicuous vegetation of certain natural subdivisions of the coastal plain, as observed in traveling from Georgia to New York in July. By Roland M. Harper. (From the *Bulletin* of the Torrey Botanical Club, vol. **37**, 1910.) N.P., [1910]. Size 9 × 6, pp. 405–428. *Sketch-map. Presented by the Author.*

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Argentine—Andes. *Z. Ges. E. Berlin* (1911): 147-172. **Kühn.**

Beiträge zur Kenntnis des Argentinischen Cordillere zwischen 24° und 26° südl. Br. (Calchaqué-Tal und Puna de Atacama.) Von Dr. Franz Kühn. *Map, Diagrams, and Illustrations.*

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Beiträge zur Kenntnis des Quebrachogebietes in Argentinien und Paraguay. Von Dr. Rudolf Lütgens. *Maps and Illustrations.*

Bolivia—Archæology. **Arlach.**

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Le territoire fédéral de l'Acre et la ligne du Madeira au Mamoré. Par Paul Walle. *Sketch-map and Illustrations.*

Brazil—Boundaries. *C.R. IX^e Congrès Int. G.* **3** (1911): 327-333. **Lima.**

Les limites actuelles du Brésil par suite des derniers arbitrages et traités. Par M. de Oliveira Lima. *Map.*

Events since this paper was written have already made some of the statements inapplicable.

Brazil—Ceará—Phytogeography. **Loefgren.**

Ministerio de Viação e Obras Publicas: Inspectoria de Obras contra as seccas; Publicação N. 2. Notas botanicas (Ceará). Por Alberto Loefgren. Rio de Janeiro, 1910. Size 11 × 7½, pp. 40. *Illustrations.*

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Les voies de pénétration au Brésil. Par M. de Oliveira Lima.

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Ministerio da Viação e Obras Publicas: Inspectoria de obras contra as seccas; Publicação N. 8 e 9. Memorias e projectos de açudes. Rio de Janeiro, 1910. Size 12½ × 9, pp. (No. 8) 108; (No. 9) 88. *Sketch-maps, Illustrations, and Diagrams.*

Brazil—Nomenclature. **José de Souza.**

Nomenclatura Geographica peculiar ao Brasil. Memoria apresentada ao Primeiro Congresso Brasileiro de Geographia realisado na cidade do Rio de Janeiro em Setembro de 1900. Por Bernardino José de Souza. Bahia, 1910. Size 9 × 6½, pp. 18. *Presented by the Author.*

Brazil, Northern. **Crandall.**

Ministerio da Viaçao e Obras Publicas; Inspectoria de Obras contra as seccas; Publicação N. 4. Geographia, geologia, supprimento d'agua, transportes e açudagem nos estados orientaes do Norte do Brazil (Ceará, Rio Grande do Norte, Parahyba). Por Roderic Crandall. Rio de Janeiro, 1910. Size 9 × 6½, pp. 132. *Illustrations and Sections.*

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Ministerio da Viação e Obras Publicas. Relatoria apresentado ao Presidente da Republica dos Estados Unidos do Brazil pelo Ministro de Estado da Viação e Obras Publicas, Dr. Francisco Sá. Rio de Janeiro, 1910. Size 9½ × 6½, pp. viii. and 606.

Gives full information on railways, posts and telegraphs, ports, etc.

Brazil—Rio. **Almeida e Silva.**

B. Ministerio Viação e Obras Publicas, Brazil **4** (1910): 7-151.

Noticia historica sobre o abastecimento d'agua da Cidade do Rio de Janeiro. Por Antonio Joaquim de Almeida e Silva.

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Le métamorphose de la capitale du Brésil. Par F. A. Georlette.

Brazil, Western—Hydrology. **Da Silva.**

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British Honduras—Archæology. **Périgny.**

Les ruines de Nakcun. Par M. le Comte Maurice de Périgny. Extrait des *Comptes rendus des séances de l'Académie des Inscriptions et Belles-Lettres*, 1910, p. 485.) Paris, 1910. Size 9 × 5½, pp. 6. *Plan.*

Peru—Phytogeography. **Weberbauer.**

Die Pflanzenwelt der peruanischen Anden in ihren Grundzügen dargestellt von Prof. Dr. A. Weberbauer. (Die Vegtation der Erde: Sammlung pflanzengeographischer Monographien, herausgegeben von A. Engler und O. Drude. xii. Bd.) Leipzig: W. Engelmann, 1911. Size 10 × 7, pp. xii. and 356. *Maps and Illustrations. Price* 18*s.*

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Commonwealth Bureau of Meteorology. Bulletin No. 6. The Physiography of the Proposed Federal Territory at Canberra. By Dr. Griffith Taylor. Melbourne, [1910]. Size 12 × 10, pp. 14. *Maps and Sections.*

See note, *ante*, p. 206.

Australia—Federal Territory. ——

Commonwealth Bureau of Meteorology. On the Climate of the Yass-Canberra District. Melbourne, N.D. Size 12 × 10, pp. 6. *Map. Presented by the Commonwealth Bureau of Meteorology.*

Australia—Fisheries. ——

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Australia—Historical. **Scot.**

Terre Napoléon: a history of French explorations and projects in Australia. By Ernest Scott. London: Methuen & Co., [1910]. Size 7 × 5½, pp. xx. and 296. *Maps and Illustrations. Price* 10*s.* 6*d. net. Presented.*

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Commonwealth Bureau of Meteorology, Bulletin No. 3. The remarkable flood rains over South-Eastern Australia during the winter of 1909. Melbourne, [1909]. Size 12 × 10, pp. 26. *Maps and Diagrams.*

New Guinea. *Petermanns M.* **57** (1911) [i.]: 184–186. **Wichmann.**

Die deutsch-niederländische Grenzkommission in Neuguinea. Von H. Wichmann. *Map.*

The map is based on the survey of Captain Sachse, one of the Dutch Commissioners.

New Guinea—German. **Spiegel.**

Deutsche Kolonialzeitung **27** (1910): 421–422, 437–438, 451–452.

183 Seemeilen im Innern Neuguineas auf einem deutschen Kreuzer. Von Freiherr von Spiegel. *Illustrations.*

New Guinea—German—Language. **Friederici.**

Pidgin-English in Deutsch-Neuguinea. Von Georg Friederici. (Sonderabdruck aus der Kolonialen Rundschau, Monatsschrift für die Interessen unserer Schutzgebiete und ihrer Bewohner. Heft 2. Februar 1911.) Berlin, [1911]. Size 9½ × 6½, pp. 92–106.

New Guinea—Kaiserin Augusta River. **Craandijk.**

Ts. K. Nederl. Aardr. Genoots., Ser. II. **28** (1911): 311–312.

De kaart der Keizerin Augusta-rivier. Door C. Craandijk. *Map.*

Reproduces the large-scale survey of the river by the Dutch section of the Dutch-German Boundary Commission.

New South Wales—Meteorology.

Commonwealth Bureau of Meteorology. Results of Rain and River Observations made in New South Wales during 1903–1908. Including all available annual rainfall totals up to the end of the year 1908 from 2298 stations. Melbourne, N.D. Size 12 × 10, pp. lii. and 76. *Maps and Diagrams. Presented by the Commonwealth Bureau of Meteorology.*

New Zealand. **Moreland.**

Through South Westland: a journey to the Haast and Mount Aspiring, New Zealand. By A. Maud Moreland. London: Witherby & Co., 1911. Size 8½ × 6, pp. xviii. and 222. *Sketch-maps and Illustrations. Price 7s. 6d. net. Presented by the Publishers.*

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Department of Mines. New Zealand Geological Survey. A Geographical Report on the Franz Josef Glacier. By James Mackintosh Bell, with topographical maps and data by Reginald Palmer Greville, and Botanical Notes by Leonard Cockayne. Wellington, 1910. Size 11 × 8½, pp. 14. *Maps and Illustrations.*

Noticed *ante*, p. 207.

Pacific—Meteorological Observations. *Met. Z.* **27** (1910): 256–261. **Linke.**

Ein meteorologisches Stationnetz in der Südsee. Von Dr. Franz Linke. *Sketch-map.*

Samoa—Apia. *M. Deutschen Schutzgebieten* **24** (1911): 43–46. **Lammert and Ambronn.**

Resultate der astronomischen Beobachtungen des Landmessers Lammert für Apia. Von Prof. Dr. Ambronn.

The co-ordinates for Apia are 171° 45′ 10″·5 W. long.; 13° 48′ 26″·6 S. lat.

Samoa—Savaii. *Z. Ges. E. Berlin* (1911): 172–180. **Sapper.**

Nachrichten über den Ausbruch des Matavanu auf Savaii aus den Jahren 1909 und 1910. Zusammengestellt von Prof. Dr. Karl Sapper. *Illustration.*

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Commonwealth Bureau of Meteorology. Bulletin No. 5. On the possibility of forecasting the approximate winter rainfall for Northern Victoria. By E. T. Quayle. Melbourne, [1910]. Size 12 × 10, pp. 8. *Charts and Diagrams.*

POLAR REGIONS.

Polar Exploration—Bibliography. **Hulth.**

K. Svenska Vetenskaps. Årsbok (1910): Bilaga 2, pp. 192.

Swedish Arctic and Antarctic Explorations, 1758–1910. Bibliography by J. M. Hulth.

Spitsbergen—British Exploration. *Scottish G. Mag.* **27** (1911): 180–187. **Brown.**

British Work in Spitsbergen: Some Historical Notes. By Dr. R. N. Rudmose Brown.

MATHEMATICAL GEOGRAPHY.

Surveying. *Petermanns M.* **57** (1911) [i.]: 87, 143–145. **Gast.**

Geographische Landesvermessung. Von Dr. Paul Gast.

Time—Arab instruments. *Naturw. Wochenschrift* **26** (1911): 241–247. **Schoy.**

Die Sonnenuhren der Araber in ihrer Bedeutung für die arabische Astronomie und Religion. Von C. Schoy. *Diagrams.*

PHYSICAL AND BIOLOGICAL GEOGRAPHY.

Geomorphology. *Z. Ges. Erdk. Berlin*, 1911: 116–124. **Groll.**

Unterseeische Gebirge. Von Dr. M. Groll. *Sketch-maps.*

Geomorphology—Deserts. *Globus* **98** (1910): 149–154. **Burmester.**

Einige Beobachtungen über tropische Schutzkrusten und Wadibildungen. Von Dr. Herbert Burmester. *Illustrations.*

Geophysics. *Riv. G. Italiana* **18** (1911): 33–45. **Marchi.**

Saggio di un teoria delle forme d'equilibrio del terreno. Di Luigi di Marchi.

Glaciers. *Z. Gletscherkunde* **5** (1910–11): 207–211. **Marchi.**

La propagation des ondes dans les glaciers. Par Luigi de Marchi.

Gravity determinations. **International Geodetic Association.**

Zentralbureau der Internationalen Erdmessung; Neue Folge der Veröffentlichungen, Nr. 20. Bestimmung der Schwerkraft auf dem Schwarzen Meere und an dessen Küste, sowie neue Ausgleichung der Schwerkraftsmessungen auf dem Atlantischen, Indischen, und Grossen Ozean. Von Prof. Dr. O. Hecker. Berlin, 1910. Size 11½ × 9, pp. viii. and 160. *Map and Illustrations.*

Some of Dr. Hecker's results were referred to in vol. **34**, p. 432.

Meteorology—Atmospheric Physics. *P.R.S.*, Ser. A, **84** (1911): 551-572. **Lamb.**

On atmospheric oscillations. By Horace Lamb. *Diagram.*

Meteorology—Precipitation. *Met. Z.* **28** (1911): 97-114. **Maurer.**

Zur Methodik der Untersuchungen über Schwankungen der Niederschlagsmengen. Von Dr. Hans Maurer. *Diagrams.*

Meteorology—Pressure. *Met. Z.* **27** (1910): 250-256. **Föyn.**

Abhängigkeit des Barometerstandes von der Terrainverhältnissen. Vertikaler Gradient. Von N. J. Föyn. *Sketch-map.*

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K. Svenska Vetenskaps-A. Handlingar **45** (1910): No. 10, pp. 20.

Ueber die Beziehung zwischen Luftdruck und Wind. Von J. W. Sandström. *Sketch-maps and Diagrams.*

North Atlantic—Temperature. **Hautreux.**

B.I. Océanog. Monaco, No. 201 (1911): pp. 24.

Températures de l'Atlantique Nord (surface et profondeurs). Par A. Hautreux. *Diagrams.*

Oceanography. **Murray.**

Exploring the Ocean's Floor. The Deep-Sea Expedition of the *Michael Sars*. By Sir John Murray. (Extract from *Harper's Monthly Magazine*, vol. **122**, March, 1911.) London: Harper & Brothers, 1911. Size 9½ × 6½, pp. 541-555, *Illustrations.*

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Oceanography—Plankton. **Ostenfeld and Wesenberg-Lund.**

Conseil Int. Exploration Mer, Publ. Circonstance, No. 48 (1909): pp. xiv. and 152.

Catalogue des espèces de plantes et d'animaux observées dans le plankton recueilli pendant les expéditions périodiques depuis le mois d'août 1905 jusqu'au mois de mai 1908. Publié par le Bureau, et redigé par M. le Dr. C. H. Ostenfeld . . . avec la coopération de M. le Dr. C. Wesenberg-Lund.

Oceanography—Sea-ice. **Drygalski.**

La Glaciation des Mers: les conditions de son développement et les faits observés. Par E. v. Drygalski. (Extrait des Archives des Sciences physiques et naturelles, Tome xxx., Octobre 1910, pp. 356 à 374.) Geneva, 1910. Size 9 × 6, pp. 20. *Presented by the Author.*

See note in vol. **37**, p. 667.

Oceanography—Tides. *C.R.A. Sc. Paris* **151** (1910): 1405-1407. **Godfroy.**

Sur quelques résultats de l'étude des marées antarctiques observés au cours de l'expédition française au pôle. Par M. Godfroy.

Snow. *Z. Gletscherkunde* **5** (1910-11): 224-228. **Marinelli.**

Forme di fusione nelle nevi dell' Etna osservate durante e dopo l'eruzione del marzo 1910. Di Olinto Marinelli. *Illustrations.*

Snow-forms. **Spethmann.**

Aeolische Aufschüttungsringe an Firnflecken. Von Hans Spethmann. (Separat-Abdruck aus dem Centralblatt für Mineralogie, u. s. w., Jg. 1909; No. 6.) Stuttgart, 1909. Size 9 × 6, pp. 180-181. *Illustration.*

Instances from Iceland of rings of wind-transported material on snowfields.

Terrestrial magnetism. **(Bauer.)**

Department of Terrestrial Magnetism of the Carnegie Institution of Washington. Annual Report of the Director, 1910. (Reprinted from Year Book, 1910; Washington, D.C.) Size 10 × 7, pp. 195-204. *Map.*

Terrestrial magnetism. **Fritsche.**

Die saecularen Aenderungen der erdmagnetischen Elemente. Von Dr. H. Fritsche. Riga, 1910. Size $10\frac{1}{2} \times 7$, pp. 28. *Sketch-maps.* [Reproduction of MS.]

Zoogeography. *Naturw. Wochenschrift* **25** (1910): 164–168. **Arldt.**

Die erdgeschichtliche Entwickelung der Tierregionen. Von Dr. Th. Arldt.

Zoogeography. **Sussbach and Breckner.**

Die Seeigel, Seesterne und Schlangensterne der Nord- und Ostsee. Von Dr. Phil. S. Sussbach und Dr. Phil. A. Breckner. (Arbeiten der Deutschen wissenschaftlichen Kommission für die Internationale Meeresforschung: B., Aus dem Laboratorium für internationale Meeresforschung in Kiel; Biologische Abteilung No. 17.) Kiel, 1910. Size $12\frac{1}{2} \times 10\frac{1}{2}$, pp. 169–300. *Charts.*

Zoogeography—Fish. **Thompson.**

Conseil Exploration de la Mer; Rapports et P.-V. **13** (1909–10): C, No. 2. pp. 32.

Second Report on the Distribution of the Cod and other Round Fishes. By D'Arcy Wentworth Thompson. *Sketch-maps and Diagrams.*

ANTHROPOGEOGRAPHY AND HISTORICAL GEOGRAPHY.

Anthropogeography. *C.R. IX^e Congrès Int. G.* **3** (1911): 106–109. **Inclán.**

Influence de la géologie sur la vie politique des nations. Par le gén. Don Julian Suarez Inclán.

Anthropogeography—Colonization. *B. American G.S.* **42** (1910): 831–840. **Verner.**

Effective Occupation of Undeveloped Lands. By S. P. Verner.

Commercial—Petroleum. *C.R. IX^e Congrès Int. G.* **3** (1911): 66–71. **Day.**

The Distribution of Petroleum. By Dr. David T. Day.

Commercial—Treaties. **Hertslet and Brant.**

Hertslet's Commercial Treaties. A collection of treaties and conventions, between Great Britain and Foreign Powers, and of the Laws, Decrees, Orders in Council, etc, concerning the same, so far as they relate to commerce and navigation, slavery, extradition, nationality, copyright, postal matters, etc., and to the privileges and interests of the subjects of the High Contracting Parties. Compiled from authentic documents and edited by Richard W. Brant and Godfrey E. P. Hertslet. Vol. **25**. London: Wyman & Sons, 1910. Size $9 \times 5\frac{1}{2}$, pp. xxvi. and 1402. *Price* 15*s.*

Communications. *Petermanns M.* **57** (1911) [i.]: 49–51. **Schulze.**

Ueber funkentelegraphische Küsten- und Binnenlandstationen. Ein Begleitwort zu den drei Funkentelegraphenkarten. Von Kapitänleutnant Erich Edgar Schulze. *Maps.*

The maps are (1) Western and Central Europe south of 60°, (2) the World, and (3) North America.

Ethnology—Architecture. **Schulz.**

Darstellungen früh- und vorgeschichtliche Kultur- Kunst- und Völkerentwicklung, herausgegeben von Prof. Dr. Gustaf Kossinna. 3 Heft: Das Grabmal des Theoderich zu Ravenna und seine Stellung in der Architekturgeschichte. Von Bruno Schulz. Würzburg: C. Kabitzsch, 1911. Size $10\frac{1}{2} \times 7$, pp. 34. *Illustrations. Price* 2.20*m. Presented by the Publisher.*

Ethnology—Slavs. **Žunkovič.**

Die Slaven, ein Urvolk Europas. Von Martin Žunkovič. 6. Ausgabe. Vienna: G. Szelinski, 1911. Size $9\frac{1}{2} \times 6\frac{1}{2}$, pp. vi. and 376. *Map and Illustrations. Price* 8*s.* 6*d.*

The first four editions appeared under the title 'Wann wurde Mitteleuropa von den Slaven besiedelt.' The work was re-cast and brought up to date in the 5th.

Historical—Route. *Z. Deutsch Morgenländischen Ges.* **64** (1910): 665–702. **Hartmann.**

Die Strasse von Damaskus nach Kairo. Von Richard Hartmann.

Traces the fortunes of this road from early times down to 1700 A.D.

History of Cartography. *B.G. Hist. et Descriptive* 1910 (1911): 259–269. **Fordham.**

Liste alphabétique des plans et vues de villes, citadelles et forteresses qui se trouvent dans le grand atlas de Mortier, édition d'Amsterdam de 1696. Par Sir Herbert George Fordham.

History of Cartography. *Deutsche G. Blätter* **33** (1910): 239–264. **Wolkenhauer.**
Aus der Geschichte der Kartographie. Von W. Wolkenhauer. Das Reformzeitalter der Kartographie.

In a previous article the author dealt with the earlier period (cf. *Journal*, vol. 25, p. 234). The two together form a handy guide to the most important cartographical documents of the past.

Industrial Geography. *J.G.* **9** (1911): 141–146. **Knirk.**
Industrial Geography, its Meaning, Scope and Content. By Carl F. Knirk.

Population. *Petermanns M.* **57** (1911) [i.]: 1–4, 60–65. **Gulischambarow.**
Die Bevölkerung der Erde und ihre Verteilung nach dem Geschlecht. Von Stephan Gulischambarow.

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Götz. *Petermanns M.* **57** (1911) [i.]: 191. **Reindl.**
Wilhelm Götz. Von J. Reindl. *Portrait.*

Prof. Götz died on March 28, 1911. His most important contributions to geography were on the historical side.

Harrisse. **Cordier.**
Henry Harrisse. Par Henri Cordier. (Extrait du Bulletin du Bibliophile.) [Chartres], N.D. Size 9½ × 7½, pp. 40. *Presented by the Author.*

Thompson. **Tyrrell.**
David Thompson: Explorer. By J. B. Tyrrell. (From "MacLean's Magazine," vol. 21, March, 1911.) Toronto, 1911. Size 9½ × 6½, pp. 64–75. *Portrait and Illustrations.*

GENERAL.

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Education. *G.Z.* **17** (1911): 65–76. **Geistbeck.**
Erdkundlicher Unterricht und Staatsbürgerliche Erziehung. Von A. Geistbeck.

Education. *C.R. IX^e Congrès Int. G.* **3** (1911): 271–280. **Telles.**
L'Enseignement supérieure de la Géographie. Par le Dr. Silva Telles.

Education—Appliances. *C.R. IX^e Congrès Int. G.* **3** (1911): 282–290. **Hobbs.**
New laboratory methods for instruction in Geography. By Prof. William Herbert Hobbs. *Illustrations.*

Education—Exercises. **Dudley.**
Exercises in practical geography on the British Isles. By Cyril R. Dudley. London: G. Philip & Sons, [1911]. Size 8 × 6½, pp. 70. *Maps and Diagrams. Price* 1*s. Presented by the Publishers.*

Geography. *Norske G. Selskaps Aarbok* **21** (1909–10): 1–4. **Reusch.**
Hvad er geografi? Av Dr. Hans Reusch.

Geography. *B. American G.S.* **42** (1910): 801–825. **Tower.**
Scientific Geography: The Relation of its Content to its Subdivisions. By Walter S. Tower.

Year-book. **Keltie.**
The Stateman's Year-Book: statistical and historical annual of the states of the world for the year 1911. Edited by Dr. J. Scott Keltie. London: Macmillan & Co., 1911. Size 7½ × 5, pp. lxxii. and 1412. *Maps. Price* 10*s.* 6*d. net. Presented by the Publishers.*

NEW MAPS.

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EUROPE.

British Isles—England and Wales. **Ordnance Survey.**
Sheets published by the Director-General of the Ordnance Survey, Southampton, from June 1 to 30, 1911.

1-inch scale maps:—
England. 3rd edit. Engraved, with hills in brown or black. Sheets: 78, 192, 194, 209. *Price* 1*s. each.*
Ditto. 4th edit. Engraved, with hills in brown or black. Sheet 274. *Price* 1*s.*
Ditto. Large-sheet series, printed in colours, and folded in cover or flat in sheets. Sheets 101, 130.
Special map of Weston-super-Mare and District. Parts of sheets 111, 112, 121, 122. *Price, on paper,* 1*s.* 6*d.*; *mounted on linen,* 2*s.*; *mounted in sections,* 2*s.* 6*d.*

6-inch—County maps:—
Cheshire, 1 sheet. **Hampshire**, 4 sheets. **Lancashire**, 6 sheets. **Lincolnshire**, 1 sheet. **Sussex**, 7 sheets. **Yorkshire**, 16 sheets. *Price* 1*s. each.*

1:2500 scale maps—with houses stippled and with areas:—
Berkshire, 4 sheets. **Cheshire**, 12 sheets. **Hampshire**, 3 sheets. **Lancashire**, 7 sheets. **Sussex**, 6 sheets. **Yorkshire**, 27 sheets. *Price* 3*s. each.*
(*E. Stanford, London Agent.*)

Germany. **Riedel.**

Isochronenkarte des Gesamtverkehrs für Mitteldeutschland mit dem Ausgangspunkt Leipzig. Scale 1:1,500,000 or 1 inch to 23·6 stat. miles. Isochronenkarte des Gesamtverkehrs für die weitere Umgebung von Leipzig. Scale 1:500,000 or 1 inch to 7·8 stat. miles. Gezeichnet von Joh. Riedel. *Petermanns Mitteilungen,* Jahrgang 1911. I. Tafeln 51 u. 52. Gotha: Justus Perthes, 1911. *Presented by the Publishers.*

Greece. **Greek General Staff.**

Map of Greece. [In Greek.] Scale 1:75,000 or 1 inch to 1·2 stat. miles. Sheets: Koniskos-Elasson; Larissa; Rapsani-Tempe; Trikkala. Athens: Greek General Staff; Vienna: K. u. K. Militärgeographisches Institut, [1910].

The basis of this new map of Greece is a trigonometrical and topographical survey of the country on the scale of 1:20,000, which was undertaken by the Greek Government some years ago, and has made considerable progress. After the termination of the war with Turkey in 1897, it was decided to discontinue the cadastral surveys of certain districts, and to commence a regular triangulation of the whole country, which has been pushed on energetically since that date. The photographic reduction of the survey sheets to the scale of 1:75,000, and their engraving and general reproduction, has been undertaken by the Military Geographical Institute of Vienna, where the work is being admirably carried out in conjunction with the Greek military officers who are responsible for the survey. The sheets are bounded by meridians and parallels, and each includes an area between 15′ of latitude and 30′ of longitude, reckoned from the meridian of Athens; while each sheet of the original survey, from which these are reduced, form a spherical trapezium of 6′ of latitude and 6′ of longitude. Relief is shown by contours at intervals of 10 metres. and by shading, which in parts is somewhat too heavy. Roads are red and water blue. When complete, the map will comprise about 120 sheets altogether, of which the above are the first issued.

ASIA.

Asia Minor. **Kiepert.**

Karte von Kleinasien bearbeitet von Dr. Richard Kiepert. Zweite berichtigte Ausgabe. Scale 1:400,000 or 1 inch to 6·3 stat. miles. Sheets: C I. Smyrna; C IV. Kaisarije; D IV. Adana; D V. Haleb. Berlin: Dietrich Reimer (Ernst Vohsen), 1911.

The most noticeable alteration on these sheets is the green tinting of the lowlying lands. Sheet D V. Haleb has received considerable revision in its eastern part, but on the others, except for one or two minor alterations, the topography is shown just as it was on the earlier editions of the sheets.

Japan. **Imperial Geological Survey, Tokyo.**

Geological map of the Japanese Empire. Scale 1:2,000,000 or 1 inch to 31·5 stat. miles. 4 sheets. Tokyo: Imperial Geological Survey of Japan, 1911. *Presented by the Director, Imperial Geological Survey of Japan.*

Russia-Caucasia. **Military Topographical Section, Tiflis.**

Map of Caucasia and adjacent parts of Turkey and Persia. [In Russian.] Scale 1:209,722 or 1 inch to 3·3 stat. miles. Sheets: Г 5, Sukhum, 8, Olti; Д 2, Petrovskoe, 3, Blagodarnoe; Е 9, Davalu; Ж 5, Khasav-yurt; З 4, Uch Peninsula, 6, Derbent, 8, Djevat, 9, Belyaswar. Tiflis: Military Topographical Section, 1896–1908.

These sheets are a continuation of the revised edition of this map mentioned in

the July number of the *Geographical Journal*. The dates of publication range from 1896 to 1909, but in most instances the corrections and alterations are very slight, and, except in the high mountain range, the sheets are much as they were in the earlier editions. It should, however, be noted that the index numbering and lettering has been changed. The relief on most of the sheets is very unsatisfactorily indicated.

AFRICA.

French Equatorial Africa. **Service Géographique de l'Afrique Équatoriale Française.**

Carte Générale de l'Afrique Equatoriale Française publiée par ordre de M. le Governeur-General M. Merlin, dressée et dessinée par G. Delingette sous la direction de M. l'Administrateur Bruel, Chef du Service Géographique. Scale 1:1,000,000 or 1 inch to 15·8 stat. miles. Sheet IV. Gabon et Moyen Congo. Paris: Augustin Challamel, 1911.

This is the fourth section of a map of French Equatorial Africa now in course of publication, and includes the area from the Congo river to the German Cameroons boundary, and from the coast to the Ubangi. Routes are shown in red, and a considerable amount of detail is given, but there is no hill-shading nor any other indication of relief.

German East Africa. **Sprigade and Moisel.**

Karte von Deutsch Ostafrika, bearbeitet von P. Sprigade und Max Moisel. Scale 1:300,000 or 1 inch to 4·7 stat. miles. Sheet C 6, Tanga. Berlin: Dietrich Reimer (Ernst Vohsen), 1911.

Morocco. **Geographical Section, General Staff.**

Town and environs of Fez. Scale: 1:21,120 or 3 inches to 1 stat. mile. [Compiled in the Geographical Section, General Staff, War Office.] London: E. Stanford, Sifton Praed, T. Fisher Unwin; 1911. *Price* 1*s. net. Presented by the Director of Military Operations.*

AMERICA.

Argentine Republic. **Stappenbeck and Domann.**

Die Vorkordillere zwischen den Flüssen Mendoza und Jachal (Argentinien). Nach eigenen Reiseaufnahme, nach Eisenbahn- und anderen Vermessungen entworfen von Dr. Richard Stappenbeck. Bearbeitet und autographiert von Bruno Domann. Scale 1:500,000 or 1 inch to 7·8 stat. miles. *Petermanns Mitteilungen*, Jahrgang, 1911. I. Tafel 53. Gotha: Justus Perthes, 1911. *Presented by the Publishers.*

Canada. **Department of the Interior, Ottawa.**

Standard Topographical Map of Canada. Scale 1:500,000 or 1 inch to 7·8 stat. miles. Sheet 31: Mattagami, Ontario. Ottawa: Department of the Interior, Topographical Surveys Branch, 1911. *Presented by the Department of the Interior, Ottawa.*

Colombia. **Rice.**

Die Forschungsreise des Dr. Hamilton Rice im Flussgebiet des Rio Caiary-Uaupés. Scale 1:1,000,000 or 15·8 stat. miles. *Petermanns Mitteilungen*, Jahrgang 1911, I. Tafel 54. Gotha: Justus Perthes, 1911. *Presented by the Publishers.*

An account of Dr. Hamilton Rice's journey was given in the *Geographical Journal* for June, 1910, accompanied by a map, which has evidently been used in the preparation of the above.

GENERAL.

World. **St. Martin and Schrader.**

Atlas Universel de Géographie construit d'après les sources originales et les documents les plus récents, cartes, voyages, mémoires, travaux geodesiques, etc., avec un texte analytique. Ouvrage commencé par M. Vivian de Saint-Martin et continué par Fr. Schrader. Carte No. I. Planisphère, 1, Bassin du Pacifique. Paris: Hachette et Cie., [1911]. *Presented by the Publishers.*

A map on Mercator's projection, showing North and South America to the right, the eastern part of Asia and Australia to the left, and the Pacific Ocean in the centre.

CHARTS.

Admiralty Charts. **Hydrographic Department, Admiralty.**

Charts and Plans published by the Hydrographic Department, Admiralty, from June 5 to July 1, 1911. *Presented by the Hydrographer, Admiralty.*

New Charts.—No. 3763, China, north coast: Ryojun ko (Port Arthur), 2*s.* **New Editions**—No. 1188, The World: Coal and telegraph chart, 4*s.* 394, England,

south coast: Spithead, 3*s*. 2631, England, south coast: Portsmouth harbour, 5*s*. 2631*a*, England, south coast: Portsmouth harbour, upper part, 5*s*. 2050, England, south coast: Approaches to Spithead, 3*s*. 2290, England, south coast: Exmouth harbour, 3*s*. 2007, Scotland, west coast: River Clyde from Dumbarton to Glasgow, 3*s*. 3557, Færoe islands: Vaag fiord, 1*s*. 6*d*. 1400, Italy, west coast: Pozzuoli bay, Castellamare bay, Port Torre Annunziata. Port Castellamare, 3*s*. 319, North America, river St. Lawrence: Quebec harbour, 4*s*. 2915, Newfoundland: Bay Bulls to Placentia, 3*s*. 2755, United States of America, east coast: Long island sound, sheet 2, 3*s*. 472, Haïti and Santo Domingo: Harbours and anchorages on the coast of Haïti and Santo Domingo, 3*s*. 3111, Central America, east coast: Colon harbour, 3*s*. 2001, South America, east coast: Monte Video bay, Approach to Cibil dock, 2*s*. 6*d*. 23, South America, west coast: Channels between Magellan strait and gulf of Trinidad, 4*s*. 1305, South America, west coast, Chile: Plans on the coast of Chile:—Port Talcahuano, Coronel bay, 2*s*. 1022, Pacific ocean: Islands and anchorages in the Pacific ocean, 2*s*.

Atlantic, North. **U.S. Hydrographic Office.**

Pilot chart of the North Atlantic Ocean, June, 1911. Washington: U.S. Hydrographic Office, 1911. *Presented by the U.S. Hydrographic Office.*

Atlantic, North, and Mediterranean. **Meteorological Office.**

Monthly Meteorological Charts of the North Atlantic and Mediterranean, July, 1911. London: Meteorological Office, 1911. *Price 6d. each. Presented by the Meteorological Office.*

Burma. **Smith and Ashton.**

Burma: Entrance to Rangoon river. Elephant point to Fairway buoy, surveyed January and February, 1911, by V. G. Smith, Assistant River Surveyor under the direction of H. G. G. Ashton, F.R.G.S., Deputy Conservator of the Port. Scale 1: 36,505 or 1·7 inch to 1 stat. mile. Rangoon: Commissioners for the Port of Rangoon, 1911. *Presented by H. G. G. Ashton, Esq., Deputy Conservator of the Port of Rangoon.*

Indian Ocean. **Meteorological Office.**

Monthly Meteorological Charts of the Indian Ocean, July, 1911. London: Meteorological Office, 1911. *Price 6d. each. Presented by the Meteorological Office.*

PHOTOGRAPHS.

Central Asia. **Coales.**

One hundred and fifty-three photographs of Central Asia, taken by Oliver R. Coales, Esq. *Presented by Oliver R. Coales, Esq.*

An excellent set of photographs taken by Mr. Coales on his recent homeward journey overland from China.

(1) Bridge at Wan Hsien; (2) A suspension bridge near Pi-k'ou; (3) A bridge on the cantilever principle near Pi-k'ou; (4) Interior of bridge near Pi-k'ou; (5 and 6) Fortified Tibetan lama monastery of Choni; (7) Young lamas at the monastery of Choni; (8) Images in the library at the monastery of Choni; (9) T'ao Chou; (10) Tibetan women of the T'ao Chou district; (11) Principal temple in the monastery of Chaki; (12) Prayer-wheels at Chaki monastery; (13) Prayer-flags at Chaki monastery; (14) Tame yak near Chaki monastery; (15–17) Lanchou Fu; (18) Temple of Literature (Wên Ch'ang Ko) at Lanchou Fu; (19 and 20) Water-wheel on bank of the Huang Ho at Lanchou Fu; (21) Floating flour-mill worked by paddle wheels on the Huang Ho near Lanchou Fu; (22) The ferry across the Huang Ho at Hsin-Ch'eng; (23) Gorge and bridge of the Tatung river; (24) Pai-ma-ssŭ or White Horse. Temple near Hsining Fu; (25) Hsining Fu; (26) The walls of Hsining Fu; (27) A scene in Hsining Fu; (28 and 29) Chinese Mohammedans at Hsining Fu; (30) Chinese school children, Hsining Fu; (31) A mission school at Hsining Fu; (32) A Tibetan "obo" near Hsining Fu; (33) Bridge over the Hsining river; (34) Yak returning to Tibet laden with barley, sugar, etc., near Dangar; (35) Mountain scenery near Donkyr Gomba monastery; (36) The Donkyr Gomba monastery; (37) The principal temple in the Donkyr Gomba monastery; (38) Young Lamas in the Donkyr Gomba monastery; (39) A Tibetan tent of the Koko Nor Tibetans; (40) Interior of a tent of the Koko Nor Tibetans; (41) The inhabitants of the tent; (42) South-east corner of Koko Nor; (43) Sunset on the shores of Koko Nor; (44) Ch'a Han Sŭŭ,

the Chinese temple to the god of the Koko Nor; (45) Interior of Ch a Han Sau (46 and 47) Kumbum monastery; (48) Entrance to Kumbum monastery; (49) Chorten covering the bones of the mother of Tsongkaba, the saint of Kumbum; (50) The Eight Chortens, Kumbum; (51) View in the glen at Kumbum; (52) Main street of Kumbum; (53) The Lesser or Lower Golden temple at Kumbum; (54) Wall paintings, Lesser Golden temple, Kumbum; (55) Wall paintings, prayer-wheels, and main entrance, Lesser Golden temple; (56) General view of the Great Golden temple, Kumbum; (57) Anterior court of the Great Golden temple, during a service; (58) Interior of the anterior or assembly hall of the Great Golden temple; (59) Rear view of the Great Golden temple; (60) The principal shrine at the Great Golden temple; (61) The sacred tree in the Great Golden temple; (62) A pavilion over a prayer-wheel at the Great Golden temple; (63) A corner of a shrine in the Great Golden temple; (64) A Buddha in one of the lesser shrines of the Great Golden temple; (65 and 66) The Great Assembly of Lamas at Kumbum; (67) Anterior court-yard of a minor temple of Kumbum; (68) The reception room of the Agia Fo-yeh or Abbot of Kumbum; (69) The Sêng-kuan at the monastery of Kumbum; (70) Mongols from the Tsaidam at the monastery of Kumbum; (71) A Tibetan and child from the Koko Nor; (72) Crossing the Hsining river at Hsining Fu; (73) A three-span cantilever bridge at Nan Mên; (74) Crossing the Tatung river; (75) A natural bridge and sulphur spring near Yungan Ch'êng; (76) Koko Nor Tibetans moving camp; (77) Pien Tou Kou, Likin barrier and temple in the Nan Shan; (78) Main street with central Drum tower, Su-Chou; (79) A guild house and police station, Su-Chou; (80) A cobbler at Su-Chou; (81) A fruit stall at Su-Chou; (82) A pedlar's stall at Su-Chou; (83) View of Chia-yü-kuan from the east; (84) View west of the gate of Chia-yü-kuan; (85) An ancient grave; (86) The east gate of Ansi Chou; (87) A Taoist temple in the desert; (88) A hamlet of ruins in the desert between Ansi Chou and Hami; (89) Travelling through the desert; (90) Scenery in the Gobi desert; (91) An inn in the desert between Ansi Chou and Hami; (92) A shrine in the desert to the "Yü Shen" or "Grease Spirit"; (93) A scene in the Gobi desert; (94) Ch'ang-liu-chui the first oasis reached near Hami; (95) Turki men at Hami; (96) A gorge in the T'ien Shan near Ch'iko-ching-tzu; (97) Mongols at Ku-ch'êng; (98) View from the walls of the Manchu quarter of Urumtsi; (99) The wall of Urumtsi; (100) The north gate of Urumtsi; (101) The south gate of Urumtsi; (102) The main street outside the south gate of Urumtsi; (103) The foreign quarter at Urumtsi; (104) Mosques of the Russian Mohammedan merchants at Urumtsi; (105) Memorial temple in the old Manchu city of Urumtsi; (106 and 107) Turki girls at Urumtsi; (108) Dungans or Chinese Mohammedans at Urumtsi; (109) Turki beggar at Urumtsi; (110) Turki women at Urumtsi; (111) Turki people at Urumtsi; (112) Turkis and Dungans at Urumtsi; (113) Blind Turki beggar at Urumtsi; (114) One of the omnibuses now running between Urumtsi and Kuch'êng; (115) High officials at Urumtsi; (116) A Hassa man near Urumtsi; (117) A Hassa woman and child near Urumtsi; (118) The main street Turfan; (119) Mosque of the late prince at Turfan; (120) Desert scenery near Karashar; (121) A Mohammedan graveyard; (122) Travelling in Chinese Turkestan; (123) A Turki village; (124) A Turki village scene; (125) Turki woman on horseback; (126) Old man and child; (127) A Turki man with hawk; (128) Turki women spinning cotton; (129) Outside the north gate of Kashgar; (130) The south gate of Kashgar; (131–134) Market-place at Kashgar; (135) Entrance to the Great Mosque, Kashgar; (136 and 137) Interior of the Great Mosque, Kashgar; (138) A sweetmeat-seller at Kashgar; (139) Turki boys making horseshoe irons for boots, Kashgar; (140) Turki men at Kashgar; (141) Water-carrier, Kashgar; (142) Camels crossing the river at Kashgar; (143) Camel, Kashgar; (144) Scene near Irkestan; (145) A Kirghiz encampment near Kashgar; (146) A Kirghiz tent; (147 and 148) Kirghiz women near Kashgar; (149) Kirghiz woman and child; (150) Kirghiz children and camel near Osh; (151) Crossing a pass on the road from Kashgar to Andijan; (152) View in the Pamirs near the Terek pass; (153) View in the Pamirs on the road from Kashgar to Andijan.

N.B. It would greatly add to the value of the collection of Photographs which has been established in the Map Room, if all the Fellows of the Society who have taken photographs during their travels, would forward copies of them to the Map Curator, by whom they will be acknowledged. Should the donor have purchased the photographs, it will be useful for reference if the name of the photographer and his address are given.

TABLE OF POSITIONS.

△ Theodolite Station in Triangulation

○ Intersected Point in Triangulation.

‡ Latitude and Azimuth Station.

† Points intersected by short bases at Latitude and Azimuth Stations.

H.p = Highest Point

Name.	Method of Fixing.	No.	Latitude.	Longitude.	Height.	Description of Stations.
Red Hill	△	3	9° 35′ 9″	41° 49′ 54″	4560	Beacon on H.p. of Hill, W. of Railway.
Middle Hill	△	1	9 36 8	41 54 33	5000	Beacon on H.p. middle of three hills, N.E. of Railway station.
Small Red Hill	△	4	9 36 54	41 51 12	—	Beacon on H.p.
G. Galawe	○	12	9 45 29	41 38 50	4650	H.p.
G. Fuldeh	○	13	9 45 56	41 33 35	4470	H.p., sharp peak.
Clump Hill	○	16	9 34 24	41 33 42	—	Point on Foothills of escarp.
G. Kulubi	○	17	9 28 25	41 38 57	7250	H.p., well-marked Clump on escarp.
	○	18	9 25 56	41 42 04	8430	,, of trees on well-marked hill above Village.
	○	25	9 29 51	42 00 36	8650	,, of Red Rock on N. edge of Harrar Plateau.
Govmt. House, Dire Daua	○	22	9 35 22	41 51 33	—	N. Gable of the House.
Dungogo	△	44	9 27 44	41 55 44	7300	Beacon point impossible to identify. Azimuth re-section.
	△	30	9 26 41	41 55 13	7380	Beacon on flat hill, S.E. of Camp; impossible to identify.
Mulata Mountains	○	31	9 07 37	41 50 38	—	H.p.
	○	32	9 03 51	41 51 26	9150	,,
	○	33	8 59 39	41 53 35	7870	,,
St. George's Church, outside Harrar	○	37	9 19 19	42 06 03	6850	Top of Roof.
	○	35	9 29 28	41 59 14	—	H p. Hill on escarp.
	○	39	9 21 43	41 42 29	—	,, Hill, South Kulubi.
Errer River	△	47	9 33 54	41 38 41	4380	,, of Old Grave (a heap of stones).
	△	48	9 33 41	41 23 14	5830	,, as seen from 3 on South edge of hill.
	△	49	9 34 12	41 27 37	3870	,, sharp cone of Western hill of low range.
G. Chalangku	○	50	9 28 34	41 33 41	7082	,, prominent hill on escarp.
Borenche	△	64	9 33 34·6	41 16 34·8	3630	,,
	△	76	9 33 12	41 11 35·4	3639	,,
	△	77	9 32 40	41 00 16	3266	,,
G. Amoissa	○	62	10 04 12·3	40 50 24·2	—	,,
G. Ayelu	○	55	10 04 56·4	40 42 06·4	6896	,,
G. Selada	△	67	9 32 23	41 14 08	3750	,,
	△	87	9 31 41	41 03 16	3336	Beacon on low hill.
G. Onde Rugdaia	○	63	9 38 18	41 01 51·8	—	H.p.
G. Rugdaia	○	27	9 40 10	41 03 11	3880	,,
G. Afdem or Afduba	○	18	9 29 54	40 50 46	6720	,,
	○	18a	9 30 59	40 45 36	—	,, of small peak on mountain.
G. Karaba	○	66	9 22 21	41 05 25	7750	,, of trees on summit.
Delado	△	83	9 23 11·3	40 56 54	3958	,, of small hill South of well.
G. Fulamo	△	88	9 19 35	40 47 29·8	4370	,, small hill North of junction of Mulu and Maiso Rivers.
G. Dalecho	△	96	9 16 11·5	40 48 26·3	4307	,,
G. Farsis	○	89a	9 13 13·4	40 39 38	5747	,, not well defined.
G. Unde	○	91	9 26 52	40 41 06·5	—	,, of twin peaks.
G. Assobat	○	93	9 00 22·7	40 50 49·6	9775	,,
,,	○	79	9 16 14·6	40 34 21·2	8180	,,
G. Bobassa	△	80	9 15 54·4	40 34 19·8	—	,, beacon.
G. Kumbi	△	101	8 56 53·3	40 15 54·5	4607	,, of very sharp peak, N.W. end of group.
Ridge North of track	△	89	8 58 50·7	40 12 44·8	4469	Cairn.
	—	—	9 02 07	40 18 02	—	H.p., hills on Escarp.
	○	110	8 38 33·4	40 17 26	9600	,, ,, ,,
	○	108	8 41 49·5	40 20 03·8	8300	,, ,, ,,
	○	111	8 44 07	40 22 39·2	—	,, on Crater edge.
G. Fantali	△	98	8 58 46	39 55 34·3	6450	,, on S.E. corner, not well marked.
G. Waldoi	△	106	8 49 08·7	40 07 47·4	5150	,,
G. Boseti	○	113	8 33 32·5	39 28 30·8	7800	Sharp peak.
G. Wasil	○	115	9 13 47·3	39 48 25	6800	H.p.
H.p. on Ankober Escarp	○	—	9 17 07	39 31 52	11820	
G. Sadeka	○	112	8 43 03	39 50 46·5	3040	
Boka	○	123	8 53 10·4	39 16 06·7	8600	
	○	120	8 19 30	39 57 41	—	,, well marked tree covered hill on escarp.
G. Amba	○	121	8 21 18	39 54 03·5	—	,, clump of trees on escarp.
T. Sirri	△	136	8 28 30	39 46 23·8	—	,, very sharp cone at foot of escarp.
G. Koloba	○	122	8 19 38·8	39 35 18·6	8100	,,
Balchi Spur	△	—	8 54 53	39 22 13	6400	Station on escarp, South of village.
	○	8	9 59 03	42 15 50	—	
	○	9	9 58 51	42 17 43	—	Rock in Plain.
	○	10	9 37 21	41 49 16	—	
	○	24	10 30 47	42 11 58	—	H.p.
G. Torma	○	14	9 36 09	41 32 16	—	Double-topped hill.
	○	60	9 29 51	41 14 10	—	
	○	61	9 29 43	41 14 02	—	
Addis Abbaba	△	92	9 02 10	38 47 38	8665	Cairn on hill at back of Residency, displaced by new Saluting Battery.
New Entoto Station	△	X	9 05 15·5	38 50 44	—	Station on high ground, N.E. of Residency.
G. Furi	○	A	8 52 58	38 41 10	9185	
G. Wochochu or Manangasha	○	B	8 58 38	38 35 35	10975	H.p.
,, ,,	○	C	8 57 36	38 35 27	10755	Cone, South of summit.
G. Faueita	○	D	9 11 56	38 30 37	10615	
Top of Gibe or Palace	○	E	9 01 28	38 45 47	7905	
S. Raguel's Church	○	F	9 05 20	38 45 01	9765	Top of roof (Station occupied close by).
G. Herrer	○	G	8 54 03	38 57 34	9905	
G. Dalota	○	H	8 46 34	38 49 28	7935	
G. Sekwala	○	I	8 32 01	38 51 29	9665	
G. Guragwe	○	K	8 23 20	38 23 37	11345	
G. Managasha	○	L	9 02 07	38 35 15	9365	
G. Kora	△	M	9 01 52	38 15 43	—	
T. Faicha	△	N	8 57 56	38 02 01	—	
G. Bote (1)	△	25	8 50 56	38 02 45	—	
,, (2)	○	26	8 51 39	38 01 34	—	
	○	28	9 01 54	38 03 00	—	
T. Jirma	○	29	9 04 59	37 59 43	—	
G. Dendi	○	30	8 48 30	37 52 12	—	
	○	31	8 49 41	37 51 42	—	
T. Unkosho	○	32	8 53 46	37 38 50	—	
G. Boke	○	33	8 58 49	37 36 41	—	
G. Khorke	△	40	8 59 52	37 40 36	—	Azimuth re-section.
G. Rogge	○	34	8 55 53	37 35 34	—	
G. Rehso	○	38	9 01 16	37 28 50	—	
G. Befti	○	36	9 00 58	37 43 02	—	
G. Wogedi	△	44	8 59 56	37 27 14	—	
Chelia Point	○	42	9 05 02	37 22 45	—	
Big Tree on Hill	○	43	9 02 37	37 26 25	—	
T. Niti	△	49	8 59 20	37 19 56	—	
G. Tibi	○	50	9 03 07	37 15 44	—	Spur.
	○	51	9 04 07	37 17 34	—	Summit.
	○	47	9 06 14	37 18 55	—	
G. Bertuma	△	55	8 56 33	37 12 02	—	Spur.
G. Jibati	△	46	8 47 01	37 27 54	—	Summit.
G. Kwunchi	△	60	8 55 13	37 02 34	—	
,,	○	52	8 51 06	37 03 53	—	
G. Tuka	○	57	9 08 15	36 43 12	—	
G. Soddu	△	53	8 54 16	36 55 22	—	
T. Soksaw	△	62	8 50 02	36 58 19	—	
G. Leka	○	63	8 40 03	36 51 17	—	Eastern summit.
G. Tuka	○	66	9 05 47	36 37 12	—	West hill.
,,	○	67	9 07 07	36 40 39	—	Spur.
Lekempti	△	71	9 05 04	36 31 59	—	The Line value West of this point is not good.
G. Digga	△	76	9 06 04	36 27 53	—	
G. Jimata	△	84	9 08 43	36 23 42	—	
T. Gonjo	△	74	9 04 30	36 25 21	—	
T. Bulo	○	79	9 26 00	36 23 23	—	
T. Avalo	○	89	9 07 18	36 22 40	—	
(?)	○	89	9 44 40	36 06 31	—	
Merechi	△	86	9 11 38	35 59 21	—	
T. Jerko	○	94	8 44 32	35 50 07	—	
G. Bikilal	○	81	9 17 31	35 52 35	—	
G. Chuta	○	85	9 07 42	—	—	

Name.	Method of Fixing.	No.	Latitude.	Longitude.	Height.	Description
			° ′ ″	° ′ ″		
Gamud Peak	△	—	4 04 32·6	38 06 57·2	8265	H.p. of the Southern of H.p. of G. Gamu viewed from Eas
Auxiliary Stn. on G. Gamud	△	—	4 05 46·6	38 06 27·9	8455	Flat rock on extreme N. of flat summit some high bush.
G. Es	○	—	4 27 55·5	38 45 31·8	5367	H.p.
G. Gubala	△	—	4 18 36·2	37 59 47·3	7729	,, of Southern & hig the same height.
G. Hobodda	○	—	4 07 40·3	37 48 07·1	5478	,,
G. Dorrorri Korma	○	—	4 34 02	38 02 09·5	5907	,,
G. Obda	○	—	4 48 51·3	38 07 09·5	7988	,, of range.
G. Obda	○	—	4 49 37·1	38 05 30·3	—	,, peak North-west o
G. Obda	○	—	4 56 36·2	38 03 26·9	—	,, sharp peak North of two peaks abo
G. Obda	○	—	4 52 02·9	38 01 46·8	—	,, low-pointed peak
G. Kunchurro	○	—	4 29 41·7	37 48 57·5	6550	,,
G. Bufe	△	—	4 21 51·7	37 46 55·9	4695	,, South end of flat s
G. Soi	△	—	4 14 42·7	37 33 04·1	4075	,, Cairn.
G. Dibbandibba	△	—	4 00 46·7	37 25 50·8	3770	,, on edge of Crater.
G. Saritti	○	—	4 55 35·9	37 41 43·4	—	,,
G. Gundile	○	—	4 53 45·8	37 25 07·4	6744	,,
G. Baldo	○	—	4 47 16·7	37 07 22·8	—	,,
G. Bube	○	—	4 49 11·6	37 12 18	6218	,,
G. Lugu	○	—	4 49 07·2	37 16 27·8	—	,,
G. Hichenni	△	—	4 34 53·4	37 05 07·8	7342	,, small grassy knoll
G. Darar	○	—	4 27 15	37 08 28	6714	Tree. H.p. rocky pea side of range.
G. Afur	○	—	4 22 15·6	37 03 40	6319	H.p., rounded grassy k
G. Jibbissa	△	—	4 13 19·1	37 04 35·9	5563	,, of the most Easte of this hill. Cair
G. Konye	○	—	4 06 02·4	37 06 32	—	,, sharp rocky peak.
G. Bollol	○	—	4 00 12·6	36 58 15·8	—	,,
Hill S.W. of G. Furroli	○	—	3 37 27·5	37 56 27·2	—	,, small hill. Difficu
Hill, Huri District	○	—	3 31 11·9	37 47 23·2	5154	,, small rise on Wes topped hill.
Hill, Huri District	○	—	3 26 09·9	37 40 51·8	5100	,, prominent hill in
Hill, Huri District	○	—	3 19 00·6	37 39 31	5000	,, prominent peak e
Mount Eslé	○	—	2 57 45	37 07 05·7	—	,, isolated hill, poin
Landslip Hill	○	—	3 21 29·8	37 05 49·5	—	,, isolated hill, with
Isolated Hill	○	—	3 20 49·5	36 36 41·7	3470	,,
Three prominent hills, S.E. of North Island in Lake Rudolf	○	—	3 46 12·6	36 24 55·9	—	,,
	○	—	3 52 01	36 30 33·7	—	,,
	○	—	3 55 08·6	36 29 20·8	—	,,
North Island in Lake Rudolf	○	—	4 03 25·9	36 03 53·9	2100	,,
S.W. Lubur Mts.	○	—	4 09 33·1	35 38 31·1	5050	,, North end of rang
Mount Lubur	○	—	4 24 30·2	35 49 30·1	5200	,, of range-peak on
Loya Hill	△	—	4 37 14·1	36 28 14·9	2989	Big thorn bush North topped hill North
Conical Hill	○	—	4 37 22·7	35 36 52·4	4370	H.p. North-west of Mo
South Peak, Lorusia Mts.	○	—	4 46 49·1	35 31 24	6143	,,
North Peak, Lorusia Mts.	○	—	4 53 10·3	35 32 09·8	5990	,, Tree.
Rocky Hill	△	—	4 58 30·5	36 22 40	3524	Rock. H.p of highest hills.
Range N.W. of Hummur Range	○	—	5 16 37·4	36 38 40·6	5991	H.p., centre flat top.
Ngalibong Hills	○	—	5 38 24	36 09 54·3	5763	,, centre of rounded
Rocky Peak, Hummur Range	○	—	5 07 17·3	36 45 21·9	7022	,, prominent rocky of range.
South Hill, Hummur Range	△	—	4 53 25·9	36 43 15·2	5930	,, centre of flat su Southerly tree o
South Hill, Hummur Range, South Peak	○	—	4 52 56·4	36 43 01·7	—	,, sharp wooded kn Hummur range or West only.
Mount Kulal	‡	—	2 43 40	36 56 34·1	7812	,, centre small oper wooded summit
Mount Indunumara	‡	—	2 12 17	36 56 36·5	5574	,, knoll on spur W.N
Mount Suddim	‡	—	1 52 51·5	36 54 15·8	6157	,, rocky summit.
Eland Range	‡	—	1 13 15·4	36 31 03·5	8715	,, wooded summit. measured base. station on wate cognizable.
Bare Hill, West of Eland Range	‡	—	1 00 32	36 33 00·7	8221	Intersected from small North end of fla
Eland Range	‡	—	1 13 28·2	36 36 49·9	8512	Biggest tree on South South of waters
Hill South of Impala Valley	‡	—	0 51 10·2	36 27 31·3	6467	H.p., North-west end
Hill East of Lake Baringo	‡	—	0 37 05·9	36 11 33·2	4824	,, Eastern summit.
CAPTAIN R. WALLER'S EXTENSION OF CAPTAIN P. MAUD'S TRIA						
G. Jima	△	—	3 58 59·5	39 28 31·8	—	Beacon on S E. end of
G. Gof	△	—	3 48 26	39 03 24	—	H.p., centre of hill.
G. Burdurras	△	—	3 52 08·4	39 52 52·4	4341	,,
G. Abagode	○	—	3 43 53·1	39 41 51·7	—	,,
Hara Reisa	△	—	4 00 20·2	39 40 23·4	3339	,, of small hill. Ve
G. Hindali	○	—	3 58 16·2	39 55 31·3	—	Boundary beacon.
G. Garsi	○	—	4 01 58·9	39 59 27·3	—	,, ,,
G. Jimoli	○	—	3 54 34·2	39 58 28·8	—	H.p., small hill of grou
G. Gamadda	△	—	3 40 09·9	39 47 19	4689	,,
G. Takaba	○	—	3 23 38·6	40 13 34·7	—	,,
G. Dandu	○	—	3 26 29·1	39 52 39·1	—	,,
G. Gugubba	○	—	3 35 05·3	39 43 43·5	—	,,
G. Kuffoli	○	—	3 21 43	39 47 38·7	—	,,
G. Gaddaduma	△	—	3 28 05·3	39 34 09·6	4640	,,
G. Errer	○	—	3 50 42	39 46 34·7	—	,,
G. Roka	△	57	3 23 43·2	39 28 21	4973	,, of centre peak.
G. Ogorchi	○	50	3 13 48·2	39 28 21·1	—	
	○	65	3 19 41·6	39 07 58·9	—	
	○	77	3 29 18·8	39 11 52·3	—	
G. Ajawa	○	60	2 56 45·4	39 43 36·7	—	
Churre Kilta	△	70	3 30 05·3	39 02 17·7	4543	
G. Burroli	△	68	3 33 09·1	38 38 24·6	5032	
G. Hoga	○	67	3 20 59·8	38 43 04·8	—	
G. Torbi	○	—	3 20 16·3	38 23 13·2	—	
G. Topeisa	○	66	3 25 34·6	39 03 31·2	—	
	○	75	2 38 11·2	38 34 59·1	—	
	○	76	3 37 09·4	38 54 55 9	—	
G. Nakua	△	7	5 05 53·1	35 54 01·8	3259	H.p.
Ngalibong Hills	△	25	5 28 46·6	36 00 50·9	—	,, sharp peak at We
	△	61	5 27 38·8	35 33 09·7	2387	,, of low hill in the
	△	28	5 32 58·1	35 43 09·3	—	,,
	△	44	5 47 19·1	35 28 15	2857	,, of conical hill in t
G. Barchu	○	37	5 54 29·8	35 20 12·5	—	,, sharp cone.
G. Kanta	○	38	6 03 15·4	35 17 39·6	6665	,, of point on escarp
G. Naita	○	8	5 30 01·9	35 19 24·6	7319	,, very sharp tree-c
G. Mwi	○	86	6 03 32·7	35 36 18·2	—	,, of point on escarp
Damme	○	69	6 06 33·6	35 25 39·6	—	,, ,, ,,
	○	80	6 11 23·9	35 30 21·9	—	
	△	34	5 46 29·1	35 20 08·6	5250	,, of hill detached f
G. Birino (Central Peak)	△	78	5 53 37·2	35 00 52·4	5086	,, Beacon.
G. Tamatiro	△	74	5 37 13·4	35 08 39·1	5877	,, on Southern end
G. Birnu, S.	○	72	—	—	—	

Description of Stations.

Southern of two rocky peaks South of
f G. Gamud; stands out prominently
d from East or West.
extreme edge of Western precipice
lat summit of G. Gamud. Just N. of
igh bush. Difficult to recognize.

hern & highest of three peaks nearly
ne height.

rth-west of H.p. of range.
eak North end of range. The Eastern
peaks about the same height.
ted peak West end of range.

nd of flat summit. Cairn.

of Crater. Cairn.

assy knoll.
rocky peak seen only from Eastern
range.
d grassy knoll.
ost Easterly of the three high peaks
hill. Cairn,
ocky peak.

ll. Difficult to recognize.
se on West side of prominent flat-
hill.
ent hill in centre of Huri District.
ent peak extreme S.W. Huri District.
hill, pointed summit.
l hill, with large landslip on N. side.

nd of range.
e-peak on flat top of N. Lubur Mntns.
sh North end of small detached flat-
hill North of prominent ridge.
rest of Mount Lubur.

of highest of this detached group of

lat top.
of rounded summit N.E. end of range

ent rocky peak West of probable h.p.
ge.
of flat summit due East of most
erly tree on summit.

vooded knoll on S. slopes of S. hill,
nur range A good point from East
st only.
small open space in centre of thickly
d summit.
spur W.N.W. of h.p. of Mt. Indunu-
ummit. [mara.
l summit. Intersected from small
red base. The latitude and azimuth
on water-shed of this range not re
able.

rom small measured base. H.p. tree
end of flat summit.
on South end of long grassy spur
of watershed Eland range.
west end of flat-topped hill.
summit.

S TRIANGULATION.

E. end of summit. Difficult to re-
of hill. [cognize.

l hill. Very difficult to recognize.
acon.

ill of group of hills difficult to recog-
[nize.

re peak.

ak at Western end of range.
ill in the Kibish valley W. of river.

l hill in the Kibish valley E. of river.
ne.
on escarp.
p tree-covered peak.
on escarp.

tached from escarp West of Kibish
river.

36°
37°
38°
39°
Limu
Horro Gudaia
Jimma
Chelia
Mecha
Chavo
None
Soddo
Gogot
Silte
Gurage
Ubarag
Abjata
Shashago
Alaba
Kambata
Walamo
Wando
Kulo
Nado
Geisha
Geira
Gemira
Kosha(?)
Chara
Gofa
Uba Gulta
Dime
Gamo
Baroda
Shabadino
Kucha
Sidamo
Tambaro
Cara Kambata
Koshi
Sorai
Omma
Leka
Leka Gumbi
Lega
Gudaia
Addis Alam
ADDIS ABBABA
Debre Berhan
Ankober
Fakisa Mts
Dadu Range
CHILLALO Mts
Lake Zwai
Lake Shala
Lake Langano
Lake Awasa
Lake Abaya
Lake Chamo
R. Didessa
R. Angar
R. Dimsa
R. Gojeb
R. Omo
R. Gibe
R. Baro
R. Ganale
R. Bilate
R. Awash
R. Hawash
R. Dukem
R. Mukki
R. Borkena
R. Gudar (to the Blue Nile)
Sibu
Mt Smith 9290
Mt Dabara 6850
Irba Modu (Boko Village)
Duga Golelcha

RECENT SURVEYS IN SOUTHERN ABYSSINIA

Scale 1 : 2,000,000 or 1 Inch = 31·56 Statute Miles

10 0 10 20 30 40 50 100 Miles

Heights in feet.

G. (*Gara*) = *Mountain*. T. (*Tulu*) = *Peak*. L. (*Laga*) *Stream*.
A. P. = *Abyssinian Post*.

NOTE.—This map is based on triangulation and latitude and azimuth fixings, made by the British Survey parties engaged on the exploration and delimitation of the Anglo-Abyssinian and Sudan-Abyssinian boundaries. The topography is, in the main, based on plane-table sketches made at the same time, but additional routes explored by the following travellers have been compiled into the map: Capt. H. H. Kelly, Dr. R. E. Drake Brockman, Mr. A. C. Hoey *(Mr. N. C. Cockburn's Expedition). The work of previous travellers has only been shown sufficiently to indicate the main hydrographical features connected with those in the surveyed areas.*

G. Boke	○	33	8	58	49	37	36	41	—	
G. Khorke	△	40	8	59	52	37	40	36	—	Azimuth re-section.
G. Rogge	○	34	8	55	53	37	35	34	—	
G. Renso	○	38	9	01	16	37	28	50	—	
G. Befti	○	36	9	00	58	37	43	02	—	
G. Wogedi	△	44	8	59	56	37	27	14	—	
Chelia Point	○	42	9	05	02	37	22	45	—	
Big Tree on Hill	○	43	9	02	37	37	26	25	—	
T. Niti	△	49	8	59	20	37	19	56	—	
G. Tibi	○	50	9	03	07	37	15	44	—	Spur.
	○	51	9	04	07	37	17	34	—	Summit.
	○	47	9	06	14	37	18	55	—	
G. Bertuma	△	55	8	56	33	37	12	02	—	
G. Jibati	○	48	8	47	01	37	27	54	—	
G. Kwunchi	△	60	8	55	13	37	02	34	—	Spur.
,,	○	52	8	51	06	37	03	53	—	Summit.
G. Tuka	○	57	9	08	15	36	43	12	—	
G. Soddu	△	53	8	54	16	36	55	22	—	
T. Soksaw	○	62	8	50	02	36	58	19	—	
G. Leka	○	63	8	40	03	36	51	17	—	Eastern summit.
G. Tuka	○	66	9	05	47	36	37	12	—	West hill.
,,	○	67	9	07	07	36	40	39	—	Spur.
Lekempti	△	71	9	05	04	36	31	59	—	The Line value West of this point is not good.
G. Digga	△	76	9	06	04	36	27	53	—	
G. Jimata	△	84	9	08	43	36	23	42	—	
T. Gonjo	○	74	9	04	30	36	25	21	—	
T. Bulo	○	79	9	26	00	36	23	23	—	
T. Avalo	○	80	9	07	18	36	22	40	—	
(?)	○	89	9	44	40	36	06	31	—	
Merechi	△	88	9	11	38	35	59	21	—	
T. Jerko	○	94	8	44	32	35	50	07	—	
G. Bikilal	○	81	9	17	31	35	52	35	—	
G. Chuta	○	95	9	07	42	35	50	54	—	
T. Wajuko	△	96	9	14	55	35	43	28	—	
T. Eriwani	△	100	9	24	19	35	37	03	—	
T. Ghinghi	○	101	9	20	59	35	41	02	—	
Fitaurari Debaba's House	○	102	9	20	41	35	36	14	—	
Guti Mudema	△	109	9	33	02	35	26	11	—	
G. Nasi	○	108	9	41	40	35	32	40	—	
T. Kasi	○	111	9	23	08	35	08	22	—	
T. Arba	○	116	9	23	06	34	50	56	—	
Point near Mendi	△	121	9	46	46	35	06	43	—	
Point on Tulu Arba	○	117	9	24	26	35	45	14	—	
Bombashi	○	—	9	42	56	34	41	17	—	
Bela	○	—	9	49	38	34	36	33	—	
	○	110	9	43	53	34	42	13	—	
Tulu Wallel	○	112a	8	53	46	34	49	51	—	Small conical hill on Plateau. H.p.
Tulu Shato	†	150	7	53	29·8	39	42	37·1	8700	
Bale	†	142	6	57	17	40	07	51	—	
	†	143	6	57	14	40	04	50	11254	
[illegible] Mountains	†	144	8	11	50·6	39	57	13	—	H.p. Three well-marked peaks on summit of
	†	[illegible]	8	12	19·4	39	57	50	11888	,, mountain, as seen from 150.
	†	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	,, castle-shaped point, South of summit.
G. Chillalo	†	147	7	42	52·8	39	24	23·5	13540	,, summit, as seen from 150.
	†	148	7	44	18·4	39	23	22	—	
Doganno	†	—	7	28	37	40	34	57	—	,, of small elevation on the edge of the escarp.
Tulu Daltu	†	141	7	42	17·3	40	12	40·7	8750	,, of sharp conical mountains of Lajo.
G. Lajo	†	149	7	13	13	39	38	40	—	,,
G. Abu el Kasim	†	140	7	43	02	40	30	21	9000	,,
G. Abdoi	†	151	8	00	00	40	17	16	—	
	†	156	7	33	27	40	42	27	—	
	†	157	7	33	27	40	41	55	—	
G. Abunawas	†	158	7	28	58	40	31	17	9030	,,
G. Arablij Dal	†	159	7	23	11	40	27	10	9500	,,
	†	162	7	41	50	40	28	37	—	
Ginir Hill	†	163	7	08	32·7	40	42	21	6940	Summit of highest house.
	†	164	7	00	25	46	47	11	—	H. p.
G. Didamos	†	166	6	57	15	40	25	49	—	
Hedabo	†	167	7	13	52	40	44	47	7782	,,
G. Gulbaduma	†	165	6	56	18	40	22	37·7	—	
Sharp Peak	†	169	7	16	34	41	10	44	6420	
G. Awatu	†	172	7	17	42·4	41	05	59	7252	,,
	†	174	6	51	16	40	21	25	—	
	†	168	7	14	42·4	40	54	43	—	,,
	†	175	6	15	28	40	24	43	—	,,
	†	181	6	42	16	41	26	35	5300	,,
Dabei	†	183	6	55	56	40	13	33	—	,,
	†	179	6	25	20	41	03	33	4130	,,
	†	185	6	13	29·5	41	33	39	—	
	†	192	6	11	59·2	41	34	17·5	—	,, of small hill near Camp.
Hada Kumbi	†	—	5	59	34	41	39	29	—	
Heili Modo	†	—	5	40	07	41	50	32	—	,, ,, ,,
Kalech	†	199	5	39	54	41	51	10·8	—	
Chaptu	†	—	5	16	04	41	53	52	—	,,
Jiji	†	208	5	16	10	41	54	52	—	,,
	†	212	4	59	43	42	12	29	—	,,
	†	211	4	59	42·7	42	12	41	—	Point on ridge just South of Malka.
	†	213	4	57	09·4	42	10	01·7	—	H.p.
Gindi Labeideir	†	—	4	42	55·6	42	04	37·4	—	
Ideli	†	—	4	27	54	42	01	53	—	Edge of kranz overlooking the river valley on
Hraura	†	217	4	32	44	42	08	53·8	—	East of river.
G. Saleh Jama	†	216	4	28	22	41	55	58	—	H.p. of low hill on East of river.
Dolo	†	223	4	10	57	42	04	34	1018	,, sharp peak.
	†	220	4	12	31·2	42	04	01	—	
G. Bangol	†	221	4	16	51·7	42	10	34	1291	
	†	222	4	09	18	42	17	08	—	
Goni Tika	†	226	4	02	42	41	56	29	—	
	†	242	3	55	49	41	49	35	—	

POINTS FIXED BY CAPTAIN P. MAUD, R.E.

British Residency, Addis Abbaba	—	—	°9	1′	42″	°38	47′	13″	8036	Grass plot on E. of Residency. Latitude observed. Longitude calculated from Swayne's.
G. Sekwala		—	8	32	01	38	51	30	—	H.p. trees South of crater.
Camp Dubisa		—	8	8	57	38	51	29	5582	On right bank Mukki River.
Camp Wurranto		—	8	1	58	38	44	15	—	On West shore of Lake Zwai. H.p. of open rise of ground.
G. Alutu		—	7	46	01	38	45	05·9	7773	North-west peak, not H.p.
G. Alacha		—	7	06	42	38	34	20·3	7060	H.p. North of dead tree on edge of precipice.
Sisha Village		—	6	40	07	38	30	26·1	8075	,, high thin cotton tree within stockade.
G. Maskulli		—	6	32	47	38	30	53·6	9055	High giant cactus tree, E. of cactus tree on H.p.
G. Honko		—	6	28	28	38	34	07·6	9289	On East side of hill; difficult point to recognize.
G. Suta		—	6	19	47	38	37	37·8	9573	H.p., Cairn.
Boka Village or Irba Moda		—	6	14	47	38	43	23·5	8774	South-west corner of stockaded village.
G. Berbissa Tuto		—	5	59	50·5	38	56	03·2	7718	H.p. of bare rocky knoll, West of forest-clad h.p.
Camp Darar	†	—	5	35	27·7		—		5492	West of road, right bank of nullah.
Camp, South Bend of Ganale River	†	—	5	29	41·3		—		—	Near mouth of Lake Uchunnuche.
Wodo Peak		—	5	17	11·9	38	59	18·6	5452	H.p. most prominent grassy peak. Cairn.
G. Derri Dima		—	4	53	55	39	11	47·8	3338	,,
G. Illadu		—	4	39	21·4	39	23	21·3	—	Highest accessible point, centre of hill North of prominent inaccessible rock, which is H.p.
G. Okoto		—	4	29	48·9	39	25	58·8	3537	H.p. flat rock.
Camp Mittita		—	4	30	32		—		4286	Near pond on high ground.
G. Dodo		—	4	12	58	39	43	53·5	3583	H.p.
G. Gurbi		—	4	31	54·2	39	11	48·9	4082	,, South-west.
G. Kajibo		—	4	13	05·3	39	00	22	5001	,, Flat rock. Cairn.
El Chillako	†	—	4	10	31		—		3127	Well.
Camp Murri	†	—	4	16	32		—		—	On stony plateau overlooking Dom Palm Grove near road.
Banissa	†	—	3	56	44		—		3298	Centre of open space containing wells.
G. Bor		—	3	29	37·5		—		4690	H.p.
G. Agal	○	—	3	36	59·5	39	09	07·6	5058	,, Cairn.
G. Tuka	○	—	3	40	50	38	50	50	5081	,,
G. Daluch	△	—	3	49	13·7	38	43	11	5326	,, Cairn. First triangulation station.
G Irrbi Kuna	△	—	3	57	58·8	38	41	44·9	5183	,, Flat rock. Cairn.
G. Yubdo	△	—	3	51	46	38	22	29·9	6427	,, Rocky peak.
G. Gomo	○	—	3	38	49	38	33	37	5035	Highest tree.
G. Shanej	○	—	3	43	07	38	29	06	5351	H.p., prominent rocky peak.
G. Furroli	○	—	3	42	56·5	38	01	40·9	6544	,, rocky peak.
G. Meg	△	—	4	06	47·8	38	19	12·4	7567	,, flat grassy summit. Cairn.

G. Gugabba	○	—	3	35	05·3	39	43	43·5	—	,,
G. Kuffoli	○	—	3	21	43	39	47	38·7	—	,,
G. Gaddaduma	△	—	3	28	05·3	39	34	09·6	4640	,,
G. Errer	○	—	3	50	42	39	46	34·7	—	,,
G. Roka	△	57	3	23	43·2	39	28	21	4973	,,
G. Ogorchi	○	50	3	13	48·2	39	28	21·1	—	
	○	65	3	19	41·6	39	07	58·9	—	
	○	77	3	29	18·8	39	11	52·3	—	
G. Ajawa	○	60	2	56	45·4	39	43	36·7	—	
Churre Kilta	△	70	3	30	05·3	39	02	17·7	4543	
G. Burroli	△	68	3	33	09·1	38	38	24·6	5032	
G. Hoga	○	67	3	20	59·8	38	43	04·8	—	
G. Torbi	○	—	3	20	16·3	38	23	13·2	—	
G. Topeisa	○	66	3	25	34·6	39	03	31·2	—	
	○	75	2	38	11·2	38	34	59·1	—	
	○	76	3	37	09·4	38	54	55·9	—	
G. Nakua	△	7	5	05	53·1	35	54	01·8	3259	H.p
Ngalibong Hills	○	25	5	28	46·6	36	00	50·9	—	,,
	△	61	5	27	38·8	35	33	09·7	2387	,,
	○	28	5	32	58·1	35	43	09·3	—	,,
	△	44	5	47	19·1	35	28	15	2857	,,
G. Barchu	○	37	5	54	29·8	35	20	12·5	—	,,
G. Kanta	○	38	6	03	15·4	35	17	39·6	6665	,,
G. Naita	○	6	5	30	01·9	35	19	24·6	7319	,,
G. Mwi	○	56	6	03	32·7	35	36	18·2	—	,,
Damme	○	49	6	06	33·6	35	25	39·6	—	,,
	○	50	6	11	23·9	35	30	21·9	—	,,
G. Birino (Central Peak)	△	34	5	46	30·1	35	20	08·6	5250	,,
G. Tamatiro	△	78	5	53	37·2	35	00	52·4	5086	,,
G. Birnu, S.	△	74	5	37	13·4	35	08	39·1	5877	,,
G. Birnu, S.W.	○	77	5	52	38·1	35	01	33·6	—	,,
	○	92	5	52	56·0	34	56	20·8	—	,,
	○	91	5	52	24·3	34	58	57·7	—	,,
Maji	△	58	6	08	34·8	35	37	05·3	8611	,,
Near Turmu	△	32	5	35	20·5	35	20	10·1	5425	,,
Near 1st Camp on Plateau	△	85	5	54	08·4	35	15	43·5	4479	,,
G. Kurmu, S.	○	89	5	32	08·7	34	47	21·8	—	,,
G. Kurmu, N.	○	90	5	36	29·9	34	44	05·7	4509	,,
Mataro	○	80	5	57	55·3	35	02	29·9	—	,,
Legedi	○	81	6	04	55·2	34	31	58·5	—	,,
Targu	○	64	6	00	50·5	35	23	31·1	—	,,
	○	111	6	16	00·3	34	58	13·7	—	,,
	○	112	6	07	37·3	34	49	16·2	—	,,
Mt. R.	○	10	5	28	44·0	35	39	19·7	4117	,,
	○	105	6	11	21·4	35	07	15·4	—	,,
	○	104	6	13	13·5	35	06	50·5	—	,,
	○	103	6	14	07	35	12	07·8	—	,,
	○	106	6	14	29·5	35	13	30	—	,,
	○	108	6	07	04·7	35	20	59·7	—	,,
	○	109	6	06	16·4	35	21	33·7	—	,,
Damme	○	57	6	05	52·1	35	24	47·7	7477	,,
G. Turmu	△	31	5	36	30·8	35	22	35·7	5733	,,
Tiski	△	51	6	05	13·7	35	34	48·3	8183	,,
	○	33	5	50	14·4	36	21	59·5	—	,,
G. Bangal	△	121	6	10	24	35	34	31·6	8218	,,
Shasha	○	115	6	26	30	35	55	36·6	—	,,
G. Bokol	○	123	6	40	06	35	04	40	7148	,,
	○	118	6	39	39	36	19	07·7	—	,,
Mt. Smith	○	117	6	35	57·7	36	26	45·2	—	,,
	○	120	6	13	52·4	36	19	02·2	9290	,,
	○	116	6	37	28·4	36	27	21·4	—	,,
	○	119	6	37	49·7	36	19	43·4	—	,,
	○	126	6	32	35·4	35	29	40·6	—	,,
	○	125	6	53	19·8	35	04	19·1	—	,,
	○	127	6	16	47·1	35	35	33·3	—	,,
	○	128	6	25	05·3	35	37	52·5	—	,,
	○	131	6	50	16·8	35	54	31·4	—	,,
	△	130	6	49	04·8	35	56	36·5	7275	,,
	○	129	7	02	27·2	36	11	05·2	—	
	○	132	6	45	51·5	35	46	04·9	—	
	○	133	6	40	50·5	35	50	57·3	—	
	○	136	6	57	00·8	35	39	34	8644	
	○	137	6	55	22·4	35	37	50	—	
	△	146	7	02	23·8	35	56	03·9	6089	
Bonga Beki	○	153	7	14	14·5	36	06	47·9	—	
Godo Gudu	○	147	7	10	20·5	36	06	06·4	7075	
Gow Guba	○	148	7	09	42·8	36	10	25·7	—	
	○	158	6	52	06·7	36	07	30·6	—	

POSITIONS FIXED BY OBSERVED

1.—Major Gwynn's Route from Malka Sala to El Wak and thence to Bani

	°	′	″			
Fino ...	3	22	55		El Wak ...	
Hara Faro ...	3	19	50		Takabba ...	
Damaso ...	3	09	22			

2.—Major Gwynn's Route to Malka Murri and Hara Reisa:—

	°	′	″			
Guba Marri ...	4	14	24·1	Camp.	Hara Dowa	
El Mole...	4	02	29	,,	Jara Hara Rei	

3.—Caravan Route Dolo to Banissa:—

	°	′	″			
Kalabad ...	3	58	40	Camp.	Muddo	
Malka Dagga ...	3	57	12	,,	Bissikka	
Malka Sala ...	3	56	15	,,	Lolafaiyu	
Yabichu ...	3	55	57	,,	Dadecha	
					Wadada	

4.—Route to Addis Abbaba:—

	°	′	″			
Laga Nadi ...	7	53	37	Camp.	Ali ...	
Karossa ...	8	08	38	,,	Jiren ...	
Laga Oma ...	8	26	50	,,		

5.—Heights by Boiling Point:—

Summit of Arussi plateau. Sokora ...	8629			Laga Darwein	
Laga Sadeika-Arussi plateau ...	8195			Chaptu ...	
Laga Daro, Arussi plateau ...	4651			Dolo Camp	
G. Abu Cassim	9000			Malka Sala	
Wabi River	3506			Muddo ...	
Donganno Camp	6795			Banissa ...	
Ginir Camp	6750			Omo River ne	
Malka Wara, Laga Diuik ...	4196			Jiren Camp	

6.—Heights obtained trigonometrically with Plane Table distances:—

Lake Stephanie ... ...
Lake Rudolf ... ...
Omo River, near Lake Rudolf ... ...

,,
,,
,,
,,
,, of centre peak.

H.p.
,, sharp peak at Western end of range.
,, of low hill in the Kibish valley W. of river.
,,
,, of conical hill in the Kibish valley E. of river.
,, sharp cone.
,, of point on escarp.
,, very sharp tree-covered peak.
,, of point on escarp.
,, ,, ,,
,, of hill detached from escarp West of Kibish
,, Beacon. [river.
,, on Southern end of summit.
,,
,,
,, of flat-topped hill difficult to recognize.
,, of low hill on escarp; a well-marked point
from the valley.
,, of low hill on plateau.
,,
,,
,,
,,
,,
,, probably the "Lady Rock" of Macmillan's
,, of sharp peak. [Survey.
,,
,,
,,
,,
,,
,,
,, well-marked point on escarp.
,, of large hill detached from escarp.
,, of point on escarp.
,, difficult to recognize.
,,
,,
,,
,, well-marked peak.
,,
,,
,,
,,
,,
,,
,, of well-marked spur on road.

ED LATITUDES.

to Banissa :—

				°	′	″
ak ...	...	...	...	2	48	23
oba ...	...	...	...	3	22	40

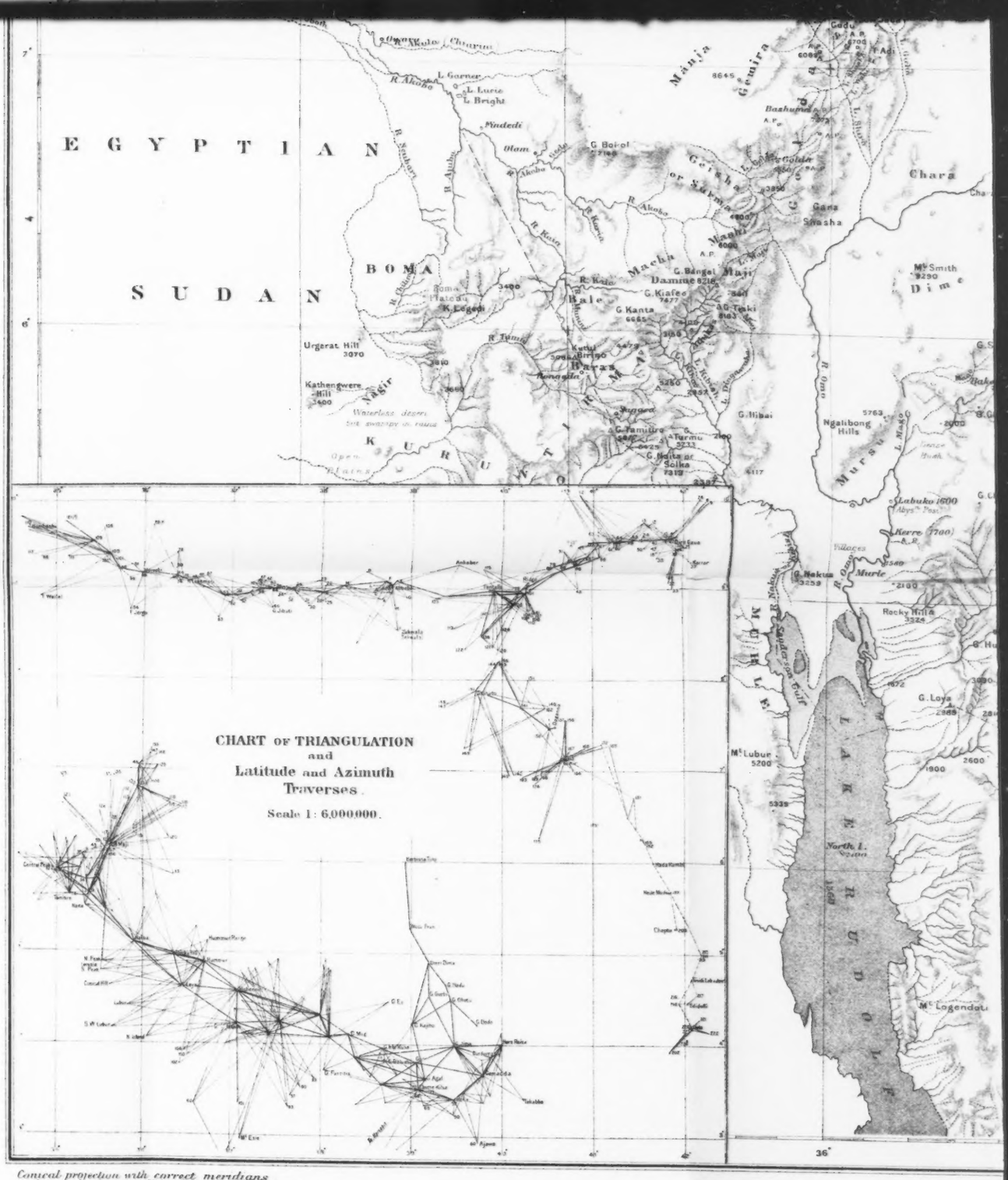
		°	′	″	
Dowa	...	4	07	32	Camp. Deduct 12" for Hara.
Hara Reisa		4	00	27·1	,,

		°	′	″	
lo	...	3	55	05	Camp in old Fort on hill.
kka	...	4	10	13	,, on river.
aiyu	...	4	01	14	,,
cha	...	0	53	47	,,
ada	...	3	57	15·7	,,

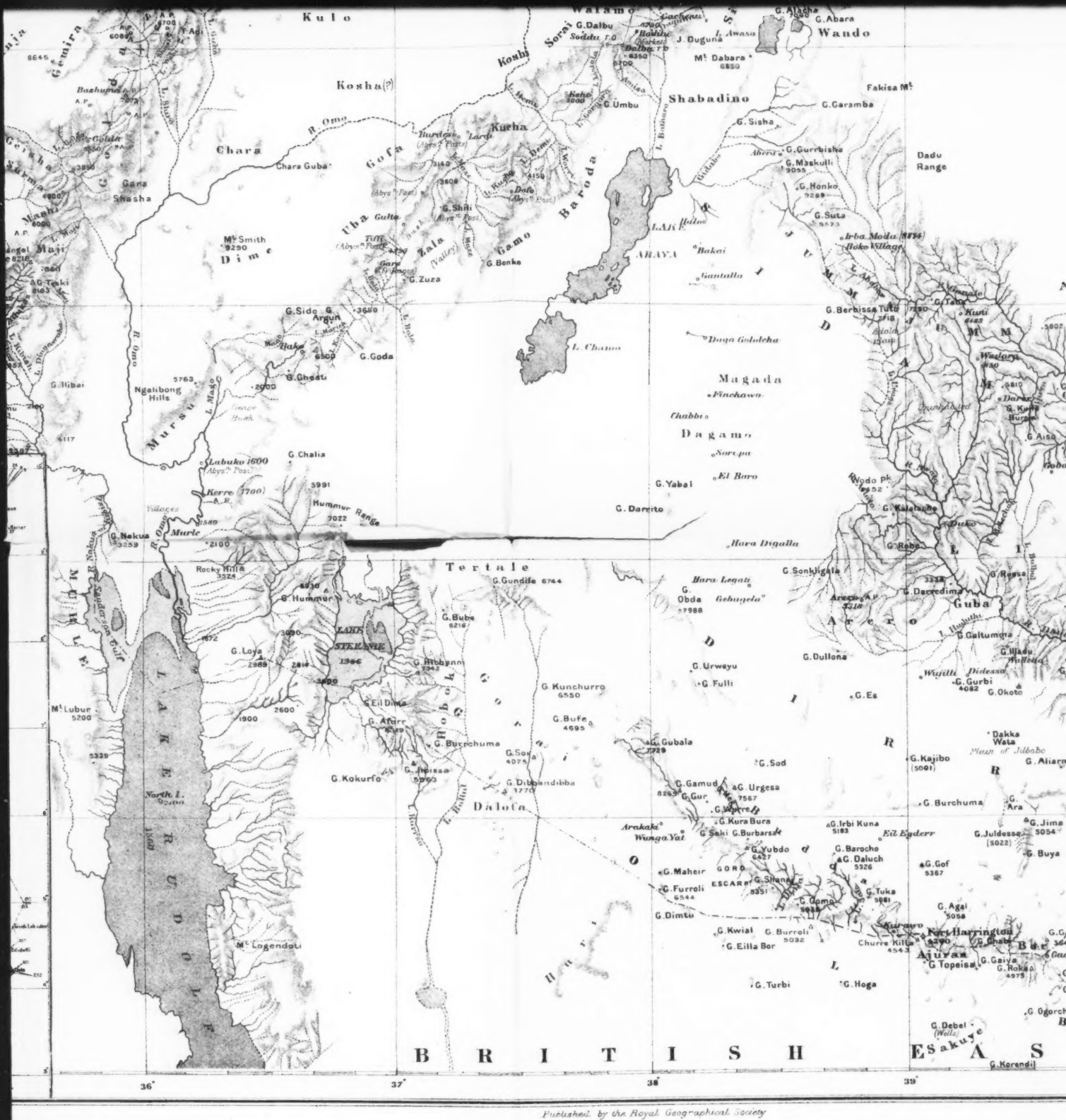
		°	′	″	
...	...	8	34	05	Camp.
...	...	7	40	35	,, in market place.

Darweina ...	... ...	2920
tu ...	... ...	1286
Camp	... ...	906
a Sala	... ...	1192
lo ...	... ...	1867
ssa ...	... ...	3531
River near Lake Rudolf	... ...	1742
Camp	... ...	5970

:—
... ... 1946
... ... 1580
... ... 1580



Conical projection with correct meridians and two errorless parallels 4° North and 9° North.



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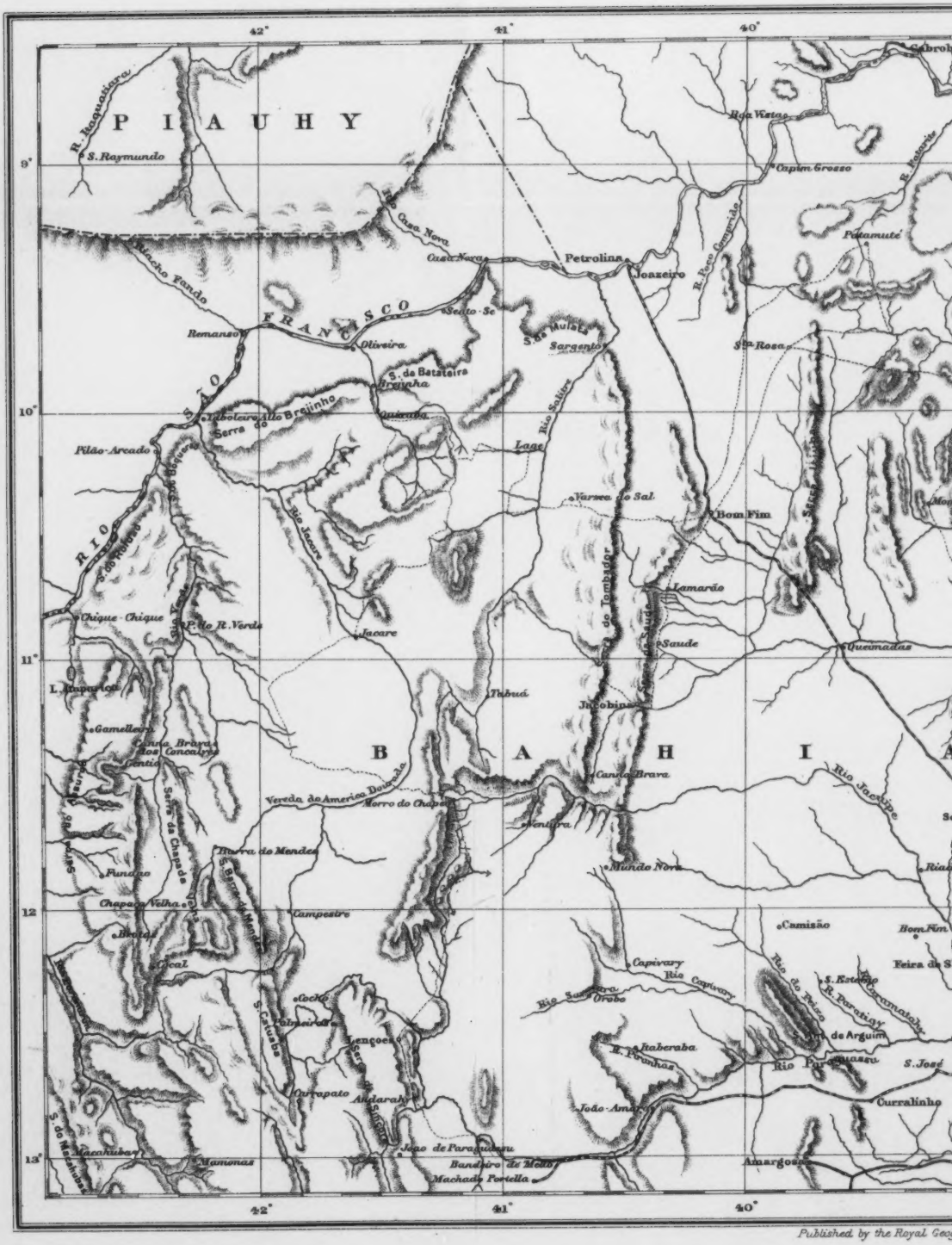
Goba
G. Dabei
G. Didamos
Kagaya
G. Gulbaduma
Berberi
Malka Wara
Oda Jida
Goro Kalo'o
El Wak
G. Galbi
G. Lale 5300
Hara Oda
Nansa
Hara Buri
G. Jabis 5300
G. Basra 2900
G. Howda 3100
Hada Kumba 1850
G. Oror
Malka Buta
Sikisa
G. Karri
G. Asia
Kalech
Dabolle
Isbilla
Gurre
Malka Choli
Kokadimit
Chaptur
Jiji
Dense bush
Dimtu (El Kadeira's)
G. Dediffi
Didu Lehan
R. Ganale
Ganale R.
Billet
Mogur
Tedsumduma
Hangetu
M. Hola
Golbo
G. el Uddoro
G. Wadel
Guba Gullgullo
Horrufi
M. Wila
Hurra Dimtu
M. Murri
Gullgullo
Chalalaka Tarba
Murri
G. Dodo 3583
G. Aliarma
Hara Dowa
El Chillaka 3127
Hara Reisa 3339
Eli Mole
Sunkutal
Malka Bissika
G. Haleiya
Jubo
Dolo 1018
R. Juba
R. Daua
G. Adaile
G. Jima 5054
G. Buya
Sali (Wells)
G. Burdurras 4341
G. Erer 4430
El Baniasa (Wells) 3294
M. Sala
Madde Erri (Wells)
Yakishu
M. Dakka
C. Beila 1050
G. Bokol
G. Alture
G. Goloh
G. Tasanei
Lugh
G. Kuretka
C Sengif
ITALIAN SOMALI LAND
G. Raiya
Garba Raiya (Wells)
Mundula (Wells)
G. Harfura
G. Gamadda 4689
G. Gaddaduma 3640
G. Dandu
G. Dirri
G. Fugugo
G. Ogorchu
G. Balobla
Kokaiya Dula 3500
Yakali (basin nearly dry)
Galguin
Burole
Marille
Den Uir
Agi Aug
Wergudud Hills
Obo
Oruba
Gogoro
L. Turre
L. Imade Garse
L. Dibuo
L. Mararo
G. Hudo
Fader Gumbi
G. Anon
G. Ghauru (Hrauru)
Ms Salajama
Edidelli
Gorallei
Giridi Labadeir
Afassi 1050
Haladeh
G. Bangol 1231
G. Bakali
G. Korai
Ganale Dorya R.
R. Web
1100
1046
1200
1400
1650
1500
1950
2130
3600
3800
3550
5300
5802
5054
4689
4341
4430
3640
3500
3339
3294
3127
3475
3583
1460
1300
1018
1231
1050


42°
41°
40°
9°
10°
11°
12°
13°
PIAUHY
BAHIA
S. Raymundo
R. Itaguaiara
Riacho Fundo
Casa Nova
Petrolina
Joazeiro
Rio Vertas
Capim Grosso
Pilão Arcado
Remanso
Oliveira
Sento Sé
Sra Mulata
Sargento
Sra Rosa
Lage
Rio Salitre
Bom Fim
Lamarão
Saude
Queimadas
Jacobina
Tabuá
Jacare
Rio Jacare
Rio Verde
Chique Chique
Gamelleira
Serra Brava
Serra do Chapadão
Morro do Chapeo
Canta Brava
Mundo Novo
Rio Jacuipe
Campestre
Camisão
Capivary
Rio Capivary
Rio Paraguassu
Rio de Peixe
Rio Sincorá
Orobó
Jaberaba
Rio Pitanga
Curralinho
S. José
Feira de S.
Serra de Sincorá
Andarahy
João de Paraguassu
Bandeira de Melo
Machado Portella
Amargosa
Mamonas
Macahubas
Serra do Mocambo
Serra do Tombador
Serra de Jacobina
Serra de Sincorá
Serra de Santa Isabel
Serra de Monte Alto
Serra de Tabuleiro
Serra de Barra do Mendes
Serra de Santa Barbara
Serra de Santa Cruz
Serra de Mocambo
Serra de Macahubas
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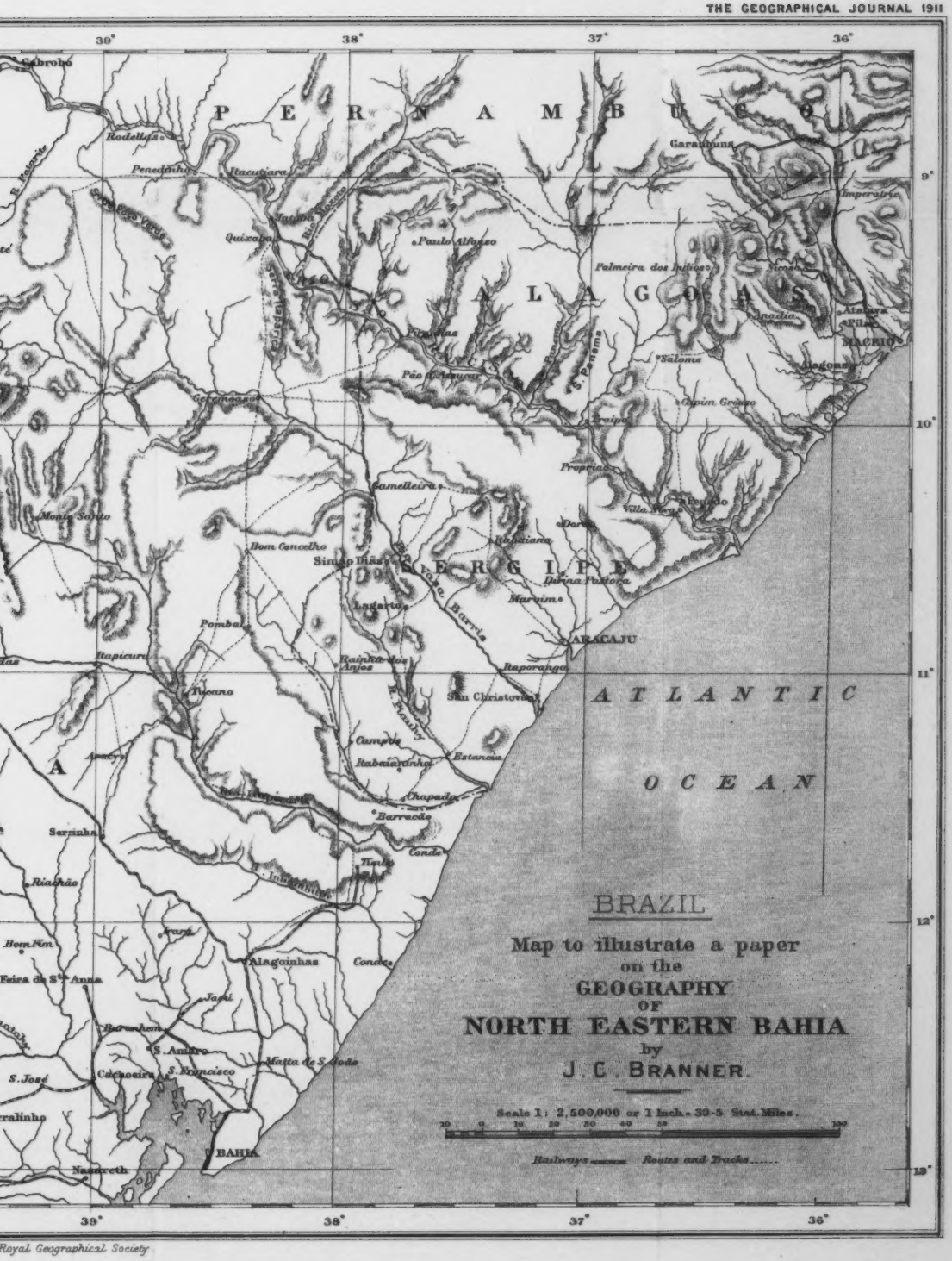

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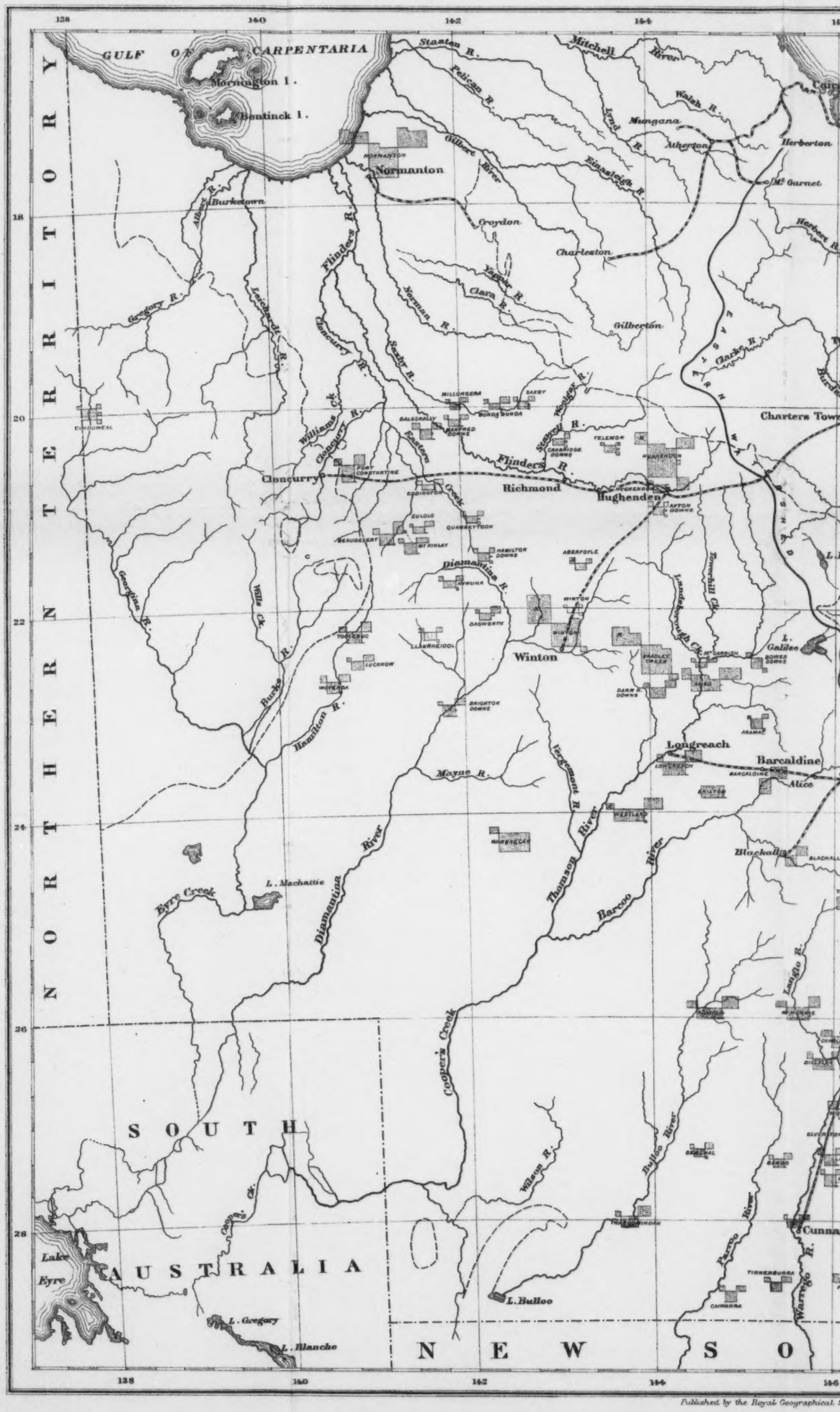

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MAP
Showing the Variation in Salinity
of the
QUEENSLAND WELL WATERS
Nat. Scale 1: 5,000,000 or 1 Inch = 78·91 Stat. Miles.
Reference.
The main Eastern Watershed
Boundary between the rocks of the basin of flowing Wells and the Palaeozoic and Pre-Palaeozoic rocks on its margin
Boundary of the Jurassic Sandstones
A-Total solids; B-NaCl; C-Na2CO3; D-MgCO3; E-CaCO3; F-KCl; Where B is marked K, the NaCl includes KCl.
In the diagrams representing the salts each 4-hundredth of a square inch equals 10 grains per gallon; thus:-
10
60
120
146
148
150
152
18
20
22
24
26
PACIFIC OCEAN
Outer edge of the Great Barrier Reef
Cairns
C. Grafton
Mackay
Rockhampton
Emerald
Gladstone
Port Curtis
Curtis I.
Bundaberg
HERVEY BAY
Maryborough
Fraser or Sandy I.
Sandy Cape
Brisbane
Ipswich
Toowoomba
Warwick
Stradbroke I.
Moreton I.
Southport
Logan R.
Dawson R.
Fitzroy R.
Burdekin R.
Mitchell
Charleville
Roma
Dalby
Goondiwindi
Cunnamulla
Warrego R.
Condamine R.
Moonie R.
Barwan or Macintyre R.
Culgoa R.
Nogoa R.
Comet R.
Isaac R.
Mackenzie R.
Bowen R.
Suttor R.
Belyando River
Burdekin R.
Ravenswood
Bowen
Townsville
Whitsunday I.
Hook I.
Shoalwater B.
Broad Sound
Curtis I.
Gympie
Kilkivan
Nanango
Kingaroy
Chinchilla
Tenningering (Mt. Perry)
Childers
Gayndah
Eungella
Clermont
Springsure
Jericho
Taroom
Blackall
Augathella
Tambo
Injune
Roma
Mitchell
Charleville
Cunnamulla
Goondiwindi
Inglewood
Warwick
Killarney
Beaudesert
Nerang
Tamborine
Logan Village
Beenleigh
Cleveland
Redland Bay
Caboolture
Gympie
Kilkivan
Nanango
Kingaroy
Dalby
Chinchilla
Miles
Wandoan
Taroom
Theodore
Moura
Biloela
Callide
Monto
Mundubbera
Gayndah
Childers
Howard
Maryborough
Tiaro
Bundaberg
Gin Gin
Mount Perry
Gladstone
Rockhampton
Yeppoon
Emu Park
Marlborough
Sarina
Mackay
Proserpine
Bowen
Ayr
Home Hill
Ingham
Cardwell
Tully
Innisfail
Babinda
Cairns
Mareeba
Atherton
Herberton
Ravenshoe
Millaa Millaa
Malanda
Yungaburra
Kuranda
Port Douglas
Mossman
Daintree
Cooktown
Coen
Weipa
Normanton
Croydon
Georgetown
Forsayth
Einasleigh
Mount Surprise
Chillagoe
Mount Garnet
Herberton
Ravenshoe
Atherton
Malanda
Yungaburra
Kuranda
Cairns